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SUBSTANTIVE THEMES SELECTED FOR DETAILED DISCUSSION

Utilization of urban wastes for energy production

Report of the Secretary-General

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INTRODUCTION

1. At its fourth session, the Committee on the Development and Utilization of New and Renewable Sources of Energy decided to include for detailed consideration during its fifth session, a theme on the utilization of agricultural residues and urban wastes for energy production. Moreover, the Committee requested the Secretary-General to prepare an analytical report for consideration at its fifth session based on an in-depth study of the current stage of achievement in States regarding this theme. 1/ The present report deals with the utilization of urban wastes only. The utilization of agricultural residues is covered in the report of the United Nations Group of Experts on the Role of New and Renewable Sources of Energy in Integrated Rural Development (A/AC.218/1990/4, annex).

2. The production of energy from solid waste is receiving increasing interest as it addresses, and has the potential for ameliorating, two serious problems at the same time - the disposal of solid waste and the utilization of indigenous renewable energy resources.

I. URBAN WASTE

3. Urban activities transform resources in ways that contribute to economic development and social welfare but also generate wastes that pollute and degrade air, land and water resources, all of which are essential to economic development and human well-being. With increasing urbanization and the growth of large cities, waste disposal is becoming a very serious problem. In many cities, a large percentage of the solid waste generated daily is collected, but after collection, more than half the waste is simply left to decompose. It should be emphasized that serious public health hazards are associated with inadequate waste collection. In other cities, solid waste is dumped untreated, creating serious air and ground-water pollution around the dump sites. 2/ Uncollected or untreated garbage creates serious human health hazards by attracting disease-carrying vermin and insects and polluting rivers, lakes, ponds, and ground water as it decomposes.

4. Population growth and urbanization have created increasing pressure to find alternatives to current waste disposal practices in both developed and developing countries. In 1950, there were 31 cities with a population of 1 million or more in the developing countries, and only 29 per cent of the world's population lived in urban areas; by 1970, the number of cities more than doubled to 77, and the percentage of urban population rose to 37.2. By the year 2000, the number of cities is projected to triple again to 279 with an urban population constituting 46.7 per cent. 3/

5. Urbanization has been rising at a higher rate in developing countries. In addition, the number of cities of all sizes is growing in developing countries, with the number and size of "megacities" (cities with populations of more than 5 million) increasing in developing countries and decreasing in developed countries. 4/

II. THE NATURE OF URBAN WASTE

6. The term "urban waste" includes both the liquid and solid components of the waste stream. The present report will focus on the solid component, which is frequently referred to as municipal solid waste 5/ and address the potential for recovering energy with particular emphasis on developing countries.

7. The typical characteristics of municipal solid waste vary by the income level of a country, as indicated in table 1. The four characteristics presented are generation, density, moisture content and composition. Waste generation tends to be greater in developed countries, although even in these countries, there is considerable variation, for example, between European countries and the United States, the latter having the highest per capita waste generation figures, approaching 2 kilograms per person per day. The density relates not only to the nature of the waste but also to the degree of compaction, which is affected by the collection system and technology. Moisture content relates not only to the nature of the waste but also to the manner in which the waste is packaged and, therefore, exposed to climatic conditions.

8. Urban solid waste is derived from residential, commercial and industrial sources, including demolition and construction wastes. The residential waste stream reflects the ability of people to purchase goods and services, the consumption of which generates solid waste. Although it is only indicative, the higher the level of average income in a country the higher the generation rate of solid waste. Societal aspects also have an important influence, so that countries with the same average per capita income levels may have markedly different generation rates as well as waste characteristics; for example, one country may have a large middle class while another country with the same per capita income may have a small upper class and a large low-income class. There are also wide variations within each class. Economic factors can make the value of such materials as newspapers and glass sufficiently attractive to warrant separation and recovery efforts for reuse or sale to third parties.

9. The commercial or business sector produces waste products that depend upon the nature of the local economy. In general, more packing materials and paper are found in the commercial waste stream. Industrial waste products also vary considerably according to the nature of the activity and the possible inclusion of toxic wastes, which pose additional hazards to air, water and land. Waste-to-energy facilities may be able to function as disposal systems for toxic waste but careful management and maintenance are required.

10. Industrial wastes also contribute to the waste-generating process. Both biological and non-biological industrial processes produce organic and inorganic solid waste, some of which can be disposed of as are other forms of urban solid waste. In addition to conventional waste, hazardous wastes are generated in limited amounts throughout most industrial activities and can pose substantial danger to human, plant or animal life in both the near and long term. The disposal of such wastes represents a matter of serious concern and expense.

Table 1. Typical municipal solid waste characteristics for low-, middle- and upper-income countries

	Low-income countries a/	Middle-income countries b/	Upper-income countries c/
Generation (kg/per capita/day)	.40 to .60	1.10 to 1.98	1.54 to 3.97
Density (wet weight basis-kgs/cubic meter)	160 to 320	110 to 210	65 to 210
Moisture content (percentage wet weight at point of generation)	40 to 80	40 to 60	40 to 30
Composition (percentage by wet weight)			
Paper	1 to 10	1 to 40	15 to 40
Glass, ceramics	1 to 10	1 to 10	4 to 10
Metals	1 to 5	1 to 5	3 to 13
Plastics	1 to 5	2 to 6	2 to 10
Leather, rubber	1 to 5	-	-
Wood, bones, straw	1 to 5	-	-
Textiles	1 to 5	2 to 10	2 to 10
Vegetable/putrescible	40 to 85	20 to 65	20 to 50
Miscellaneous inerts	1 to 40	1 to 30	1 to 20
Particle size	5 to 35	-	10 to 85

Source: S. J. Cointreau, Environmental Management of Urban Solid Wastes in Developing Countries, A Project Guide (Washington, D.C., World Bank, June 1982).

a/ Includes countries having a per capita income of less than $US 360 in 1978.

b/ Includes countries having a per capita income of more than $US 360 and less than $US 3,500 in 1978.

c/ Includes countries having a per capita income of more than $US 3,500 in 1978.

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11. In examining the solid component of the urban waste stream from which energy would be derived, the composition of the solid waste component is of considerable interest. It varies from country to country depending on the state of economic development and other social conditions. In developed countries there is a higher content of paper and other combustible material, while in the developing countries there is a higher moisture content due to the contribution of vegetable and putrescible materials, which arise from the daily purchase of fresh foods using less packaging materials and the lack of garbage disposal systems (and often sewage systems) in dwellings (see table 1).

12. In addition to the higher percentage of organic matter in developing countries, less paper is used, and that which is present is often recovered prior to disposal. The result is that the waste available in developing countries has a lower heat content (BTU value) per kilogram so that less energy is released in the combustion process. Furthermore, wastes in tropical climates are characterized by higher moisture content from both the sources themselves and from the lack of protection from exposure to the elements after collection.

13. When waste water is filtered or treated in purification plants, the material removed forms sludge, which can have a role in the energy recovery process. The final disposal of sludge poses environmental problems, since it is difficult to handle and process and may contain harmful substances. It is possible to burn sludge as part of a total waste-to-energy system, although it will yield little energy. If the sludge is not dried prior to incineration, the energy required to remove the moisture content may, in fact, exceed the energy produced. If sludge is to be reused, its composition must be determined with particular regard to the presence of heavy metals, toxins and other sources of pollution. Nevertheless, environmental factors may dictate the inclusion of sludge in an overall waste disposal system. The treatment of municipal sludge, the residue from waste water and sewage treated in purification plants, is relevant to waste-to-energy systems and should be considered at an early stage of planning. Sewage is more than 99.8 per cent water with organic solids in suspension or solution. However, a comprehensive waste management scheme would require a thorough examination of the means of handling the liquid component.

III. CONTRIBUTIONS OF URBAN WASTE TO ENERGY

14. The potential contribution of municipal solid waste to energy supplies can be illustrated in the case of the United States, which produces approximately 240 million tons of municipal solid waste each year. 6/ The total raw energy content of this waste is equivalent to that of 340 million barrels of oil. Moreover, the recovery and recycling of the 40 million tons of reusable materials (aluminum, iron, glass and other inorganics) contained in municipal solid waste could conserve an additional 175 million barrels of oil by reducing the amount of energy required to produce the virgin materials. Therefore, the total energy potential of municipal solid waste in the United States is equivalent to about 500 million barrels of crude oil per year.

15. In the case of paper, the combustion of 1 kilogram of newsprint produces 65 per cent of the net useful energy of 1 kilogram of coal (17,000 BTU) and the recycling of the same kilogram of newsprint conserves 4,400 BTU and recycles 0.85 kilograms of the paper fiber (.15 kilogram is lost in processing); however, the 0.85 kilograms of recycled newsprint may be recycled again to conserve an additional 3,700 BTU, and so on.

16. While such figures illustrate the potential of combustion, they are misleading in that the construction of a combustion facility which can capture the energy contained in solid waste is costly, and the value of the energy derived alone will not support its installation and operation. In addition, smaller cities with lower amounts of waste will have an even more difficult economic equation to solve since the facilities have significant economies of scale. Nevertheless, the contribution to energy supplies can be significant, particularly in major cities, and other economies can be gained when they are used in combination with conventional power plants.

17. The management of urban waste includes collection, transfer, treatment, resource recovery and final disposal. It is a multidisciplinary activity requiring the expertise of sanitary and civil engineers, economists, urban and regional planners, public health officials, environmentalists, sociologists and legislators.

18. Methods for waste disposal, which vary considerably by country, include recycling, composting, incineration, landfill and open dumps, several of which are capable of conserving energy or producing additional supplies.

19. Although very little refuse is disposed of in open dumps in developed countries, it is the primary methods of waste disposal in many developing countries. Because of the adverse impact on human health and welfare, it is becoming environmentally unacceptable in many countries. At the same time, the operation of a "sanitary" landfill involves labour and equipment costs which frequently run quite high in the long run, in addition to being unwelcome, particularly near residential areas. Among the resource recovery options, recycling through source separation and materials recovery through mechanical separation of mixed solid waste components have only limited application because of the uncertainty of the markets for recovered materials. Recycling of 5 to 20 per cent of the solid waste stream appears to be a practical limit at the present time.

20. Solid waste disposal constitutes a large expense for cities of all sizes with costs increasing with city size. In addition, littering and unsupervised dumping have environmental costs in the form of pollution and the creation of health hazards. More acceptable options, such as sanitary landfills, which require daily covering over of deposited refuse, are more costly, and environmentally safe incineration is still more costly. Disposing of solid waste in landfills with daily cover, including control of the leachate, costs about $US 20-60 per metric ton, while incineration costs are projected to be $US 150-200 per metric ton in developing countries. Many cities in developing countries now spend over 30 per cent of their budgets on refuse collection and disposal. 7/

21. Among the options for the disposal of municipal refuse is the combustion of processed or unprocessed urban waste. The energy thus released, which may be utilized directly as process heat or captured in the form of steam, can be used in turn to generate electricity. Resource recovery through thermal processing offers an opportunity to greatly reduce the volume of solid waste requiring landfill disposal while at the same time producing revenues from the sale of recovered resources to help offset the cost of solid waste disposal. Energy recovery through thermal processing results in a significant reduction in the weight and volume of material requiring landfill disposal and thus extends the life of available landfill capacity. Furthermore, the character of the material requiring landfill disposal is such that it can be disposed of more easily and with less adverse environmental impact than disposal of unprocessed solid waste.

IV. WASTE MANAGEMENT TECHNOLOGIES AND PRACTICES

22. There are a number of approaches (not necessarily in current use) for producing energy from waste, including mechanical processing, thermochemical processing and biochemical conversion. Mechanical processing includes shredding, magnetic separation, density separation, screening, non-ferrous separation and various wet processes that use water to effect the separation. Mechanical processing does not change the chemical composition of the waste and usually is a preliminary step in the energy recovery process which permits recycling.

23. Thermal processes may be divided into combustion, gasification and pyrolysis, depending on the amount of air used. When municipal solid waste is subjected to thermal processing, a mixture of solid, liquid and gaseous fractions are produced.

24. Biological conversion changes the composition of processed or unprocessed waste in order to recover the heat released in the chemical reaction or change the waste into a more manageable form. Bio-conversion includes anaerobic digestion, enzymatic hydrolysis and the production of landfill gas and produces such products as combustible solids, compost and methane-rich gas. Each of these approaches is described below.

A. Mechanical processing

25. Several technologies have been developed for the mechanical processing of municipal solid waste in order to recover salvageable materials or facilitate further treatment or disposal. These include physical separation (either at the source or at the disposal site), baling, pulverization and the production of refuse-derived fuel (RDF), which will be discussed under thermal processing.

26. Whereas mechanical processing does not directly produce energy, it does perform two basic functions - homogenization (or size reduction) and separation. One form of homogenization is pulverization, which can lead to better incineration. After the raw waste has been shredded to a more manageable size, it may be separated into a number of components at which point the non-combustible matter can be removed to improve the fuel and or accomplish recycling. Another

approach is the separation of urban wastes at their source. Such an approach is being mandated in many locations, very recently in New York City, but requires a comprehensive redesign of the entire waste management system. In addition, manufacturers should be encouraged to change packing techniques to less wasteful and more environmentally benign forms.

27. The recycling process has an important indirect energy benefit as a form of energy conservation, since the value of its products is almost entirely determined by the cost of the energy required to produce the same items from virgin materials. There are two types of recycling. The first involves source separation, which is the segregation of specific solid waste materials at the point of discard so that they can be collected in concentrated and relatively uncontaminated form; the second is the mechanical processing of the mixed solid waste at a centralized plant to separate out recyclable and saleable materials. The prime recyclable materials are aluminium, paper, iron, steel and glass (see table 2). Other potentially recyclable materials include plastics, food wastes, tires and other metals.

28. The recycling of metals and glass would benefit the resource recovery project since it would reduce the quantities of inert materials in the solid waste stream, reduce maintenance costs and increase the heat content. A major benefit of recycling in conjunction with resource recovery would be a reduction of non-combustible residue that would require landfill disposal. The value of recoverable material is, in part, related to the energy conserved in its remanufacture to new materials. Table 3 lists certain recoverable materials for which recovery and energy conservation estimates have been made in the United States.

29. A frequent concern of recycling is the compatibility of source separation and energy recovery; the removal of paper, for example, reduces the energy content of the refuse. In fact, however, the removal of as much of the recyclable paper and plastic as feasible will remove only 5 per cent of the energy content of the waste, while the removal of the inorganic material (particularly aluminium, with its low melting point) will improve the efficiency and reduce the maintenance costs of the system. As a result, there is no conflict as long as the tonnage itself is not necessary to the economic operation of the plant, and the recyclable combustible components find an attractive economic market.

Table 2. Recovery rates for aluminium, paper and glass, 1985

(Percentage)

	Aluminium	Paper	Glass
Netherlands	40	46	53
Italy	36	30	25
Federal Republic of Germany	34	40	39
Japan	32	51	17
France	25	34	26
United Kingdom	23	29	12
Austria	22	44	38
Switzerland	21	43	46
Sweden	18	42	20
United States of America	28	27	10

Source: C. Pollack, Mining Urban Wastes: The Potential for Recycling, Worldwatch Paper 76 (April 1987).

Table 3. Additional data for the United States of America, 1984

(Percentage)

	Aluminium	Paper	Glass	Magnetic metals
Amount available (Mt)	0.8	16.0	15.2	13.6
Amount recoverable (Mt)	0.5	8.0	9.7	11.6
Energy savings potential (kJ/t)	281.0	17.3	2.9	49.0
Total energy savings (GJ)	140.5	138.4	28.3	577.7

Source: H. Alter and J. Dunn, Jr., Solid Waste Conversion to Energy (New York, 1980), as quoted in D. K. Walter, "Municipal Solid Waste Conversion", in D. O. Hall and R. P. Overend, eds., Biomass (New York, John Wiley, 1987), pp. 175-200.

B. Thermal processing

30. Thermochemical systems are designed to change municipal solid waste into energy forms, such as heat to produce hot water or steam for electricity generation or other application or into a more valuable fuel form, such as methane gas. More than 500 systems world wide are burning waste to produce steam, but there are few commercial-scale systems producing gaseous fuel from waste.

31. The distinguishing characteristic of thermal systems is the amount of oxygen made available to process the waste. If sufficient oxygen is available to complete the oxidation of the components, then the system is an incinerator. If the oxygen supply is restricted, the oxidation is less complete; the resulting products comprise a range of combustible gases, liquids and solids.

32. In the United States, municipal solid waste contains about 3,750 to 5,250 BTU/lb (2,000 to 3,000 kcal/kg) of solid waste. In developing countries, where the paper and plastic content is lower, the calorific value is considerably less. For an estimated recovery efficiency of 67 per cent, a reasonable assumption for thermal conversion processes using solid waste as a fuel, each ton of solid waste processed would yield 6 million BTU of energy. Given current energy costs which are approaching $20 per barrel, the value of oil that could be replaced by energy from solid waste is equivalent to over $50 per ton of solid waste. In the United States, where a city of 100,000 produces about 150-200 tons per day, the combustion for energy would result in a saving of $5,000-10,000 per day or $1.5 to $3.0 million per year. Of course, such savings would be applied to defray the capital cost of the waste-to-energy plant and its operational and maintenance expenses.

1. Combustion

33. The disposal of solid waste in open fires is an age-old process, which not only produces high levels of air pollution with odours, gases and particulate matter but does not generally permit the recovery of the heat for other purposes. Although open fire combustion of waste is still practised on a wide scale, it should be phased out as part of an effective waste management programme.

34. Incineration refers to the controlled combustion of municipal solid waste. Refuse is burned at temperatures of from 900° C to 1,000° C. The odour of the flue gases is removed by ensuring that the combustion gases pass through a zone of temperatures greater than 800° C. These hot gases must be cooled to about 300° C and cleaned of particulates before being discharged into the atmosphere. As noted, the energy released through thermal processing may be recovered in the form of heat, which may be used to generate steam through water-cooled walls in the upper part of a furnace or by passing the hot gases through a heat exchanger. The steam itself may be marketable or may be used to generate electricity, for which there is almost always a ready market. Heat recovery efficiency ranges from 55-70 per cent, while the net heat recovery from electricity generation is about 14-22 per cent. Thermal processing still involves land disposal of the residue that remains after processing, which is approximately 10 per cent by volume of the incoming waste.

35. Mass burning refers to the combustion of municipal solid wastes "as received", with minimal processing and the recovery of the energy from the gaseous combustion products. Mass burn systems can be field-erected or factory preassembled depending on size. Individual units capable of burning up to about 120 tons of solid waste per day can be largely preassembled and erected with a minimum amount of field labour. Larger units must be shipped in sections and assembled at the site.

36. Mass-burn, waste-to-energy systems consist of the following main elements: the mechanical handling of the waste, the combustion system, the energy recovery system and the environmental control of the solid, liquid and gaseous emissions and residues. Each phase of the technology for energy recovery from urban wastes has become increasingly sophisticated in order to deal with the variable composition of the "fuel".

37. In order to recover steam for process heat, district heat, electricity or cogeneration, combustion takes place in large combustion chambers and boilers. If the combustion chamber is lined with refractory material and the energy recovery takes place in a separate boiler, the system is known as a refractory furnace and waste heat boiler system. If the combustion chamber is constructed with boiler tubes constituting the furnace walls, the boiler is known as an "integral waterwall boiler". Typically, the smaller units use refractory-lined waste heat boilers, and the larger units are of the integral waterwall boiler type. In all combustion systems, the control and distribution of primary (underfire) and secondary (overfire) air is of crucial importance in achieving good burnout, complete combustion and efficient energy recovery.

38. Mass burning of municipal solid waste is a mature technology which developed rapidly, particularly in Europe, where traditional systems were designed with refractory-lined furnaces and waste-heat boilers. The purpose of the refractory-lined furnaces, as opposed to the water-tube wall furnaces, was to retain and radiate heat so as to keep the combustion process going, even when charges of low heat value (BTU) refuse were fed into the furnace. This was particularly important in the 1940s and 1950s because of the lower heating value of the refuse at that time.

39. In the 1960s and 1970s, however, the heating value of refuse increased considerably both in the United States and in Europe, because a greater increase occurred in the percentage of highly combustible packaging materials (such as paper and plastic). At the same time there was a concurrent demand for both the construction of larger units and higher energy efficiencies as waste burning plants began to be thought of more as power plants than as incinerators. As a result of these trends, the integrated water-tube wall furnace/boiler came into wider use or for the production of high-temperature steam.

40. Various types of mass-burn incinerators have been developed. They can be classified into continuous grate direct incinerators and the recently proposed batch-loaded modular incinerators.

41. While most preassembled systems burn solid waste on a solid hearth, field-erected units use a mechanical grate. The grate distributes the air and

agitates the fuel bed while the use of a hearth limits the degree of burnout achievable and the amount of energy released. For the most part, these systems are modular and can be combined as independent "trains", which allows routine maintenance to take place without a complete loss of waste processing capacity. The modular-controlled air system has two combustion chambers in which the air to fuel ratio is carefully controlled. Most of the organic matter decomposes in this stage and the unburned organic matter, together with the exhaust, pass under low turbulent flow conditions to a secondary chamber where combustion in an excess-air environment takes place at temperatures of from 1,000° C to 1,200° C. The combustion of organic material is quite complete and little inorganic material is contained in the flue gases. In the single combustion chamber system, the addition of an expensive wet scrubber or electrostatic precipitator is required in order to meet standards for air quality. The modularity also allows for later expansion of the plants through the construction of additional modules. Plants are frequently planned with sufficient floor space and the over-sizing of other components to permit subsequent installation of additional modules.

42. Most small-scale systems use a bucket-equipped tractor to load solid waste from a tipping floor into charging hoppers; a hydraulic ram then pushes the solid waste into the combustion chamber. The larger systems use a storage pit; the solid waste is picked up with an overhead bridge crane and dropped into a charging hopper and feed chute of the furnace. The waste is fed into the furnace by gravity, by motion of the first section of the grate or by a charging ram. The use of the pit allows the operator to mix the solid waste to form a more uniform fuel, thus obtaining more uniform combustion conditions. It also allows the plant to operate over periods when there is no solid waste delivery, or to temporarily accept solid waste in excess of facility capacity.

43. The capital costs of field-erected systems tend to be higher than those of factory preassembled systems. However, projected energy recovery efficiencies are also higher. There is also significantly more long-term operating experience with field erected systems than with preassembled units. World wide, mass burning in field-erected furnaces with waterwall boilers is the most widely used technology for disposing municipal solid waste and recovering energy from these wastes. There are over 300 field-erected mass-burn facilities with capacities in excess of 100 tons per day currently operating in Western Europe, some with over 20-30 years of operating history, about 100 in Japan and over 100 in the United States. Table 4 indicates the trend in waste-to-energy plants and greater recycling in five communities in the United States.

44. Although these plants generally are modular, there is a considerable economy of scale which favours large cities and regional concentrations of populations. One centrally located plant might encourage the pooling of wastes and create a more economic solution to a large-scale problem.

Table 4. Waste management trends in five United States communities

(Percentage)

		Recycling	Reduction	Waste-to-energy	Landfill
Essex County, New Jersey	1988	15		0	85
	1991	25		60	15
Dade County, Florida	1988	15		30	70
	1994	30		35	25
Babylon, New York	1988	8	2	0	90
	1991	23	4	63	10
Indian, Wisconsin	1988	20		70	10
	1990	20		70	10
Spokane, Washington	1988	20		0	80
	1994	33		55	12

Source: Jonathan V. L. Kiser and Lisa M. Gills, "Integrated Waste Management: The Crisis Solution", Waste Alternatives, vol. 2, Washington, D.C. (March, 1989), pp. 40-48.

45. Nevertheless, very small-scale systems may prove viable in large buildings for the production of hot water, which would reduce the overall demand for energy from conventional sources. Unfortunately, most research into this method of resource recovery has not concentrated on small-scale waste-to-energy systems (those burning less than 500 tons of waste per day), which are well-suited to small cities (population 25,000 to 250,000) as are found in many developing countries.

46. Refuse-derived fuel (RDF) is a solid fuel prepared by processing raw municipal solid waste to reduce fuel particle size and noncombustible content. A wide range of technologies have been developed to produce RDF. These technologies differ markedly in the production methods used, their state of development, quality and the form the RDF takes. RDF is used to fire specially designed "dedicated" boilers or is used in existing utility boilers, possibly in combination with pulverized coal or other fuels, although such combined fuel plants have experienced severe operational problems. The initial concept, which originated in the United States 15 years ago, provided for size reduction by trammelling, shredding and separation of the light and heavy fractions by air classification. Between 50 and 75 per cent of the solid waste is converted into RDF. Some systems recover marketable materials, for example, from the non-fuel portion. Pulverization and magnetic separation is the simplest and least costly procedure to produce RDF.

47. Two distinct systems have been developed - one uses RDF as a supplemental fuel in existing utility boilers in combination with coal as the primary fuel; the other treats RDF as a primary fuel in boilers specifically designed for it as fuel. Some RDF plants provide extensive processing of the solid waste; depending upon fuel specifications, such plants shred and separate refuse using a variety of processing components. Combustible components are separated out and processed into RDF. Other components, in particular metals and possibly glass, are recycled. Materials not suitable for recycling or recovery as fuel are deposited in landfills. Most existing boilers will require some modifications in order to burn RDF. Handling facilities must be constructed to receive, store and convey the prepared fuel to the boiler.

48. The RDF approach has the potential to supply fuel to a number of different burning facilities. Long-term experience with these systems is limited, however. Mechanical separation systems that have been built to date have been designed for three purposes: the recovery of specific materials for recycling; the recovery of refuse derived fuels (RDF) to be used in an existing boiler; and the production of fuel for a special boiler designed for the RDF. In the United States, 22 plants have been built; of these, the two designed to recover materials have both been closed as neither was able to develop acceptable markets for the product and both had technical problems that could not be solved. Eleven were constructed to recover RDF of which four were operational in 1987, selling RDF to existing utility boilers. Nine plants were built to provide fuel to a dedicated boiler. 8/

49. Pulverized RDF produces a fuel whose burning characteristics are close to those of powdered coal. Pulverized RDF has also been cofired with oil on an experimental basis, but experience is even more limited, and no operating systems are currently using this technology. The densification RDF to produce briquettes or pellets has also been investigated, but the high cost of densifying and the lack of identified markets for densified RDF make this technology non-commercial at present.

2. Pyrolysis

50. During the 1970s, several systems were developed for pyrolysis, which is the thermal decomposition of organic matter under oxygen-deficient conditions resulting in partial oxidation and producing intermediate products that could be used as fuel in a combustor. Depending on the specific process, the fuel product could be in gaseous, liquid or solid form, or sometimes a combination of the three. Full-scale facilities have met with only limited success, and at the present time, pyrolysis systems are not considered commercial, particularly in developing countries.

3. Gasification

51. Gasification refers to the reaction of organic matter with an insufficient amount of oxygen than would be required to ensure the complete combustion. Gasification generally produces a fuel gas diluted with combustion products and nitrogen. Gasification has not reached the pilot plant stage and thus has not been proven on a commercial scale.

C. Biological conversion

52. Biological processes utilize organisms or the products of organisms to change municipal solid waste into fuel. In controlled reactors, municipal solid waste is generally processed into an RDF, while in uncontrolled reactors, the solid waste is used in its as-received form. An example of a controlled reactor is one which converts solid waste to sugars for fermentation to ethanol; is a sanitary landfill naturally degrading organics to methane and carbon dioxide; is an example of an uncontrolled reactor. There are three major biochemical systems at advanced stages of research and development for commercial applications: anaerobic digestion to produce methane-rich gas; fermentation of cellulose to glucose for further conversion to ethanol; and composting.

1. Anaerobic digestion

53. Anaerobic digestion of municipal solid waste involves the decomposition of the organic fraction of the solid waste in the absence of air. Under these conditions, decomposition in a digester produces about 40 per cent carbon dioxide and 60 per cent methane, the latter of which may be used as a fuel. In a plant, solid waste is shredded, ferrous metals are extracted and grit and fines are screened out in a trommel. The resulting RDF is fed into a mechanically agitated, steam heated anaerobic digester. The residue is disposed of in a landfill.

54. Compared with mass burning, the energy efficiency of this process is relatively low. Continued testing and evaluation must be performed before the process may be considered ready for commercial application. Its use, however, would eliminate the combustion of the waste, which is a costly component of the mass burn system due to the cost of the environmental safeguards required for air and water pollution control. Most current plants use a single digester, but multi-stage digestion is the focus of new systems. The gas from the digester contains about 60 per cent methane, the remainder being mostly carbon dioxide. The remaining slurry must be de-watered if it is to be used as a fertilizer. The viability of the anaerobic digestion of municipal solid waste is yet to be proven.

2. Landfill gas recovery

55. It has long been recognized that a consequence of the burial and subsequent decomposition of wastes containing organic materials in landfills is the generation of landfill gas, principally methane and carbon dioxide. A landfill site is a biological system in which municipal solid waste decays over time in the presence of entrapped air and moisture. As a result, aerobic bacteria multiply rapidly, and the resultant decomposition raises the temperature in the landfill. As the oxygen is used up, anaerobic bacteria replace the aerobic bacteria, and the methane produced by natural decomposition of organic material in the landfill can be recovered. At present, however, landfill gas is essentially a by-product of the disposal process and is a danger to both the safety and property of nearby residential areas. Landfill gas recovery systems can make the gas available for direct sale to nearby facilities, for natural gas pipelines or for electricity generation.

56. Although there are many sites that are potentially hazardous and many that have existing problems, there is an increasing awareness that landfill gas can be a valuable asset capable of commercial exploitation. In the United Kingdom, for example, where approximately 90 per cent of municipal, commercial and industrial wastes are landfilled, landfill gas with an energy content equivalent to over 120,000 tons of coal is being exploited. It is estimated that 28 million tons of refuse are generated each year in the United Kingdom and of this vast quantity, approximately 20 million tons are potentially able to produce landfill gas.

57. The potential for gas production is great, and as a result, a new industry is evolving in several countries to maximize gas generation and extraction using new techniques for gas enhancement, control, collection and utilization. The major objective is the reduction of the hazards for uncontrolled migration of subsurface gas and uncontrolled emissions. Gas recovery does not necessarily control migration, but migration control schemes can be designed in conjunction with monitoring and ventilation systems. Safety precautions are essential since the gas is flammable and explosive and its presence must never be forgotten.

58. In Wisconsin, United States, methane gas is used to generate 9.9 megawatts of electricity, sufficient to meet the needs of 15,000 homes. The systems use more than 8 kilometres of collection pipe to extract .9 million cubic meters (9.5 million cubic feet) of gas daily. The gas passes through water-wash scrubbers en route to compressors, each of which is driven by a 600 horsepower motor. The compressors deliver the gas to turbines at a pressure of approximately 185 pounds per square inch (psi) and a temperature of about 70° C (125° F). The compressed gas then enters the combustion chambers, where it burns at a temperature of from 825° C to 875° C (1500° F to 1600° F). Each turbine can turn at rates up to 4500 horsepower, enough to generate 3.3 megawatts of electricity.

59. Amidst the enthusiasm for the utilization of landfill gas, it should not be forgotten that a properly managed sanitary landfill is required - landfill gas cannot be obtained from an open dump. Modern landfills should include multiple safeguards to contain wastes and isolate them from surrounding water and soil. A "state-of-the-art" landfill is very costly to construct and maintain.

60. These stringent requirements are becoming common in many developed countries that have recognized the continued necessity for proper landfill design and operation. The projected costs for waste disposal in landfills in the United States, including predevelopment costs, construction costs, operation costs, closure costs and post-closure care, is over $20 per ton. 9/

3. Ethanol

61. A series of biological processes convert municipal solid waste to ethanol which can be used as an automotive fuel additive or in other thermo-chemical applications. Most work on fermentation has concentrated on wood and agricultural wastes, and it is expected that it will be applicable to solid waste. Solid waste conversion has five discrete steps: (a) the concentration and pretreatment of the cellulosic and carbohydrate components; (b) the conversion of those components to sugars; (c) the fermentation of the sugars to ethanol; (d) the distillation of the ethanol/water mixture.

4. Compost

62. Composting involves the aerobic decomposition of organic matter to form carbon dioxide and a stable, humus-like material which can be used as a soil conditioner. Composting has been proposed as a method for disposing of municipal sewage treatment plant sludge. A demonstration plant for composting sludge has been in operation in Maryland, United States, since 1979. However, the composting of solid waste is considerably more difficult because of the presence of inert components, principally metals, glass and plastics. Although the number of composting facilities have decreased in many developed countries, its potential is strong in many developing countries, where these inert materials are present in lesser quantities.

63. Much of the waste is placed directly on farm land, tilled into the soil and allowed to decompose. The potential environmental impact of this practice has been a major concern, as has the safety hazard to farmers and plow animals from the metal and glass mixed in with the waste. Fields that receive waste are identifiable by the plastics which are scattered throughout the soil.

64. Waste from cities is also taken to the countryside. In China, such waste is delivered to large, fenced-in areas, referred to as "heap sites". Waste is left in these sites for several years and allowed to decompose, after which farmers may take the material to their fields after sorting out non-compostable materials, which are collected and sold. Mechanical systems to segregate compost from non-compostable material and accelerate the composting process have received much attention as a means of increasing interest in composting.

D. Combined cycles and other alternatives

65. If a steam market can use only a portion of the steam produced at a resource recovery facility, or requires steam at lower pressures than that at which it can be produced, it is possible to increase energy revenues by utilizing a cogeneration system, which yields both steam and electricity as marketable products. Two types of cogeneration cycles are possible: a topping cycle, in which steam is first passed through a back pressure turbine and then transmitted to the user, and a parallel cycle, where a variable steam quantity is transmitted to the user and the rest used to produce electricity. Sometimes both forms of cogeneration can be combined in one system.

66. While information on the experience in developing countries is not readily available, a study has been done on Egypt which concludes that it is technically feasible, economically viable and socially beneficial to convert a large proportion of urban waste into energy. 10/ It states that resource and energy recovery systems are therefore viable alternatives for the resolution of the critical waste disposal problem in some countries of the Economic and Social Commission for Western Asia (ESCWA) region. It further states that a properly planned waste management programme that would utilize the various kinds of waste available in a given country for the production of energy could reduce the cost of fuel oil used for the generation of power in addition to enabling the recovery of valuable

by-products. It should be emphasized that the main purpose of a waste-to-energy system is to render municipal solid waste disposal safe, efficient, environmentally sound and economically attractive. Energy generation is an attractive adjunct but is not the primary reason for the installation.

V. ECONOMIC CONSIDERATIONS OF WASTE-TO-ENERGY INSTALLATIONS

67. The determination of the economic feasibility of recovering energy from urban solid waste is a complex process that requires a broad and rather detailed study of the availability of domestic sources of energy, the cost of imported energy, the uses and actual benefits from energy generation, the public and private costs associated with waste collection, as well as the technology used to generate the energy. Since these factors are country and site specific, the evaluation of a potential municipal solid waste energy recovery project must be considered in its entirety with particular regard to the reliability of the quantity of waste - the waste stream.

68. The feasibility is dependent upon obtaining the maximum revenue from the energy that can be recovered directly by the thermal processing of solid waste to produce steam. The steam can be delivered directly to a steam user or converted into electricity, which could then be delivered into the utility grid. Energy recovered as steam is potentially more valuable than electricity. Steam from solid waste replaces fossil fuels directly, so that its market value could be viewed as that of the fossil fuel it replaces.

69. The value of the energy as electricity depends upon how much it would have cost the utility to produce the additional electricity, which is not solely dependent upon the price of fossil fuel if electricity is generated from hydroelectric sources. Even when the value is set by fossil fuel cost, it is likely to be less than the value of steam sold directly, because the efficiency of utility boilers and generators is higher than those of resource recovery facilities. If a suitable steam market is available, such as a brewery or newspaper plant, it is likely to result in the lowest net cost for solid waste disposal.

70. Markets for steam, however, are more difficult to find than markets for electricity. Steam cannot be stored and can only be transported over limited distances. A waste-to-energy facility that plans to market steam must be located in the vicinity of the steam market. In evaluating steam markets, it is necessary not only to analyse the average requirements but also the variations over time and the availability of sites within economical transmission distance.

71. It should be noted that although municipal solid waste has a relatively high energy value, it cannot be utilized as easily and economically as conventional fuels due to its variable content and less convenient form. The viability of a waste-to-energy system depends upon the cost of competing conventional fuels, the actual energy content of the solid waste and the cost of conventional alternative disposal methods. These costs should be considered along with the fact that many solid waste items may have a recycling market value.

72. Other factors that may affect the economics and cost effectiveness of a waste-to-energy facility include:

(a) Government regulations covering solid waste disposal and, in particular, landfill sites;

(b) The effects of the facility on air and water quality;

(c) Transportation, handling and processing costs;

(d) The costs and effectiveness of alternative municipal solid waste disposal methods;

(e) Landfill availability and costs;

(f) Resource recovery;

(g) Conventional fuel costs and supply.

73. On the basis of plants that have been built in Europe and the United States, mass-burn waste-to-energy plants are considerably more costly than conventional power plants fueled by coal or oil. It is expected that the cost of such a waste-to-energy plant will run four to five times the cost of a conventional oil or coal-fired power plant. The capital cost will also depend upon the air and water pollution control devices and the desired longevity of the facility. In developing countries, where there is a need to reduce the necessity for frequent maintenance and repair, the capital costs of systems are likely to be greater.

74. In general, mass-burn waste-to-energy plants are economically viable where the costs of alternate waste disposal is high. Although the high costs are often associated with a scarcity of urban land and concomitant high land values, it is of growing importance that the costs of environmental degradation be considered when calculating the feasibility of a project.

75. The experience of communities in developed countries indicates that the capital cost of a waste-to-energy installation cannot be economically recovered solely through the production and sale of energy in the form of process heat, steam or electricity. In these countries, the cost of waste disposal is often so great that "tipping" fees are paid to the plant on a "per ton" basis to augment the revenues from the sale of energy. Tipping fees in the United States, for example, have soared in communities that have closed their landfills due to the presence, real or perceived, of harmful substances which can affect ground water and cause other forms of environmental degradation.

76. When municipal solid waste must be transported over long distances, the costs of disposal may exceed $100 per ton and the economic feasibility of waste-to-energy plants at or near the source then becomes highly attractive. At the same time, it may be attractive to use one centralized facility to serve a number of communities in one area. Nevertheless, environmental sensitivity has extended to the safety of waste combustion technologies, and concern has been voiced regarding the hazards posed by air emissions as well as by the disposal of the residual ash in land fills.

77. However, there are other considerations, including the environmental and social costs of unsound disposal practices. The plant should in fact be viewed as a waste disposal facility whose energy production is a bonus that assists in defraying its cost. Consequently, the recovery of energy from urban waste should only be considered where alternative disposal methods are (or will be) very costly or where environmental impacts are sufficiently severe so as to pose a threat to the public welfare.

78. As a rule, energy revenues are a minor component of the revenues compared to tipping fees. Energy revenues may be significantly increased by combining the waste-to-energy system with a conventional oil- or coal-fired power plant, if there is a need for additional electricity-generating capacity. The interaction of the two plants can be designed to increase their efficiency resulting in more economical energy production. The electricity generated could assist in subsidizing the cost of the municipal solid waste plant.

79. However, the economic situation that prevails in communities in Europe and the United States is not generally found in developing countries. The costs of waste disposal in developing countries have generally not reached those of developed countries so that the costs avoided by using the waste-to-energy plant will not supply the same level of revenue. Nor is it acceptable that environmental safeguards be reduced to lower the costs of the facilities in developing countries. What is required is a comprehensive examination of the waste disposal methods and options and an evaluation of the long-term environmental costs associated with dumping or landfilling.

VI. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

A. Environmental considerations

80. Although municipal solid waste is disposed of because it has no economic value, it is widely recognized that failure to safely dispose of these wastes can create environmental and public health hazards that have serious consequences, including visual degradation of the living environment, local air pollution from the burning of waste, significant fire hazard to makeshift wood/paper shelters in such settlements, massive proliferation of insect and rodent pests and vectors of disease, emission of offensive odors and clogging of surface water drainage conduits and channels. Even without the economic benefits of recycling products of economic value, the costs of environmentally proper disposal of the combustible components with or without the recovery of energy must be weighed against the cost of the continued environmental degradation caused by the non-collection or non-disposal of municipal solid waste.

81. Five basic environmental impacts must be considered in implementing a waste-to-energy system: (a) atmospheric emissions; (b) waste water discharges; (c) residue disposal; (d) noise impacts; and (e) local and in-plant environmental impacts, including worker health and safety. Each phase of the technology for energy recovery from urban wastes is becoming increasingly sophisticated in order to deal with the variable composition of the "fuel". The degree of technical

sophistication required for the management of the liquid, gaseous and solid waste products of combustion will depend on the environmental criteria established for the operation of such a facility. Such decisions reflect the individual perceptions of communities and Governments since there are no widely accepted standards.

1. Air quality

82. The combustion of any fuel results in the release of the products of combustion, some of which are considered air pollutants. The level of stack emissions from a waste-to-energy plant can be controlled to a great extent by the installation of air pollution control equipment. The impact on ambient air quality of the resulting emissions may be further mitigated by dispersion after the combustion products are discharged from the stack. National standards have been established in many developed countries for certain pollutants because of their demonstrated negative impacts on public health. These include total suspended particulates, sulfur dioxide, carbon dioxide, photochemical oxidants, nitrogen dioxide and lead, as well as contaminants released in the combustion of plastics, which may contribute to damage to the ozone layer. In the United States, for example, two levels of standards have been established. Primary standards are intended to protect public health, while secondary standards are intended to protect against adverse effects on materials, vegetation, wildlife and other environmental values. Individual States have added to the list of pollutants and created more stringent standards than the national criteria.

83. Air emission control devices include baghouses, electrostatic precipitators and other control systems, which can significantly increase the cost of the facility. However, these devices may not remove all potentially harmful emissions. Further action is required to address this problem.

2. Water quality

84. Waste water at a waste-to-energy facility is generated in the form of wash water, boiler blow-down, ash quench water, sanitary wastes and surface runoff. Some of these may be recycled to reduce their environmental impact.

85. Except for sanitary wastes and surface runoff, waste water at a waste-to-energy facility typically is recycled in a closed-loop system. Any impacts on ground water at the facility site from the incineration residue and/or fly ash can be minimized by proper handling practices. All waste water should be treated in compliance with local water quality standards before being discharged to the sanitary sewer system. Treatment may include settling to remove any suspended solids and adjustment of pH within limits acceptable by the sewer system.

3. Residue disposal

86. The combustion of municipal solid waste in a waste-to-energy system generates four solid residues that must be disposed of: siftings, dust, bottom ash and fly ash. Typically, they are combined for the purposes of collection and disposal. The total solid waste residue from a waste-to-energy facility amounts to approximately 5 to 15 per cent by volume and 30 to 46 per cent by weight (wet) of the incoming refuse. In this regard, how much residue a system generates is highly dependent upon how it is operated, that is, whether a greater priority is placed on burnout and thermal efficiency (but reduced waste throughput).

87. The mixture of bottom ash and fly ash from a waste-to-energy facility is typically not a hazardous waste unless industrial wastes are included which contain heavy metals or other contaminants. An extraction procedure may have to be installed which would take periodic samples to monitor the composition of the residue.

4. Other environmental considerations

88. Associated with every facility that receives or processes raw municipal solid waste is the potential for odor, traffic, land-use and aesthetic impacts. In this regard, typically the malodorous air within a plant can be prevented from escaping to the ambient air by keeping the facility at a negative pressure and then utilizing such air for combustion air within the incineration system to destroy most odors. Siting considerations, including alternative routing of collection vehicles, can reduce the other impacts. Little or no public criticism or opposition to local or in-plant environmental impacts at any small-scale (less than 500 tons per day) waste-to-energy system has been recorded in the United States.

5. Toxic waste disposal

89. The disposal of toxic and hazardous wastes is not contemplated for municipal solid waste disposal facilities in urban areas. Special precautions are required for the collection, transport, handling and disposal of these wastes, which vary according to the specific substances. The costs of these additional precautions is considerably greater than the requirements of handling municipal solid waste because of the hazards posed to the environment and public health.

90. The transport of hazardous wastes across national boundaries has become a matter of great concern to the international community. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was drafted in March 1989 to address that concern. 11/

91. In summary, potential environmental degradation and health-related problems with conventional solid waste disposal methods, together with the lack of adequate areas for sanitary landfill, have become the major impetuses for considering incineration with energy recovery. Waste-to-energy systems involve less risk than continued landfill and alternative disposal methods, and their use also reduces the

potential for ground-water contamination, the consumption of fossil fuels and mobile air emissions due to a reduction in truck miles for transporting solid waste. Environmental control for biochemical conversion processes are readily available for many of the modern combustion and thermochemical options. The planning process for evaluating the costs and benefits of installing a waste-to-energy facility should include the cost of taking no action.

B. Social considerations

92. Social factors have a bearing not only on the quantities and characteristics of the waste produced but on the attitudes to waste disposal as well. As average income rises in a country, increased money is usually spent on waste disposal. High-income countries tend to have a higher portion of solid waste going to landfill, incineration, energy recovery and composting than countries with lower income levels where open dumping is more prevalent. Scavenging from discards prior to collection, particularly from wealthy neighborhoods and at dump sites, is a common practice in many middle- and low-income countries. Control or even elimination of scavenging is a typical practice when urban areas develop landfills to replace open dumps.

93. Waste generation and disposal pose an increasingly serious problem to all urban areas whose solution will depend upon the unique characteristics of the individual country and even the specific urban area. National issues concern the attitude towards environmental quality and public health as well as the relations between the central and local community Governments. Since the costs of building and operating a waste disposal facility cannot be recovered from the sale of energy alone, decisions regarding the sharing of costs among the various sectors of society - residential, commercial, industrial and governmental - must be considered.

VII. CONCLUSIONS AND SUGGESTIONS FOR FURTHER ACTION

94. The above discussion on waste-to-energy has drawn largely from the experiences of developed countries simply because few facilities for the extraction of energy from waste have been built in developing countries. This is due primarily to the relatively high capital cost of waste-to-energy plants and the apparently low cost of conventional waste disposal in many developing countries. However, with the expected growth of urban populations in developing countries, serious attention will need to be given to the issues and problems associated with waste-to-energy conversion, especially in the light of the fact that a number of technologies for such processes are technically proven and reliable.

95. However, the recovery of energy from waste is a complex and sophisticated process whose viability is directly related to social, political, environmental and economic factors. In particular, the installation of a waste-to-energy facility requires a comprehensive approach, including questions of waste management for which guidelines are required. To determine the viability of waste-to-energy facilities, it is vitally important to consider the cost of alternative waste disposal options. When the costs of certain waste disposal practices may appear to

be low, when the costs of environmental degradation and clean-up are taken into account, a different picture emerges.

96. Given the advantages of economies of scale, larger plants and facilities to serve the needs of a number of urban communities in close proximity to each other, rather than those of a single urban area, would have greater economic viability and deserve consideration. There is, in that connection, a need for long-term planning that should anticipate and incorporate, to the extent possible, such issues.

97. It is of crucial importance for developing countries to formulate policies for waste management and, in particular, waste-to-energy conversion facilities and to determine how best to incorporate them into overall national energy and environmental planning.

98. Limited information is available on the current experience in developing countries necessary for the satisfactory evaluation of the economic viability of waste-to-energy facilities. Such information should be obtained and information gaps identified.

99. Countries without environmental quality criteria for air and water emissions which apply to waste-to-energy plants should consider establishing them. Such criteria should cover both local and regional effects.

100. There is a need for a comprehensive assessment of the environmental costs of unsanitary waste disposal practices, such as open dumping in comparison with those associated with the costs/benefits of waste-to-energy options, including the role of recycling.

101. In addition, the following concerns merit further consideration: (a) the need for basic data collection to help define and analyse the potential waste-to-energy options; (b) the need to develop more appropriate and less costly waste-to-energy systems that are suitable for developing country application; (c) the need to promote pilot and demonstration projects in developing countries so as to move beyond the speculative stage; and (d) the need to co-ordinate the activities of promoters of waste-to-energy options in developing countries so as to minimize duplication and build on previous experiences.

Notes

1/ Official Records of the General Assembly, Forty-third Session, Supplement No. 36, annex (A/43/36).

2/ United Nations, Population Growth and Policies in Mega-Cities, Jakarta, ST/ESA/SER.R/86 (New York, 1989).

3/ United Nations, Prospects of World Urbanization, 1988 (ST/ESA/SER.A/112, New York, 1989), p. 4.

4/ Ibid., p. 8.

Notes (continued)

5/ Some insight into the extent of the solid waste problem is afforded by the Special Report on Public Attitudes Toward Garbage Disposal by the National Solid Wastes Management Association (U.S.A.), April 1989, which includes the following statement: "Each day, the citizens of the United States of America produce 1.6 kilograms [of solid waste] per day - over 150 million tons per year. That is enough to cover 1,000 football fields with a building 30 stories high."

6/ The actual figures are difficult to ascertain; for example, there are questions of how to obtain figures for solid waste from the total waste stream. In the United Kingdom, for example, estimates as high as 500 million metric tons have been given for the total waste produced without indicating what portion of that amount is municipal solid waste.

7/ United Nations, The Prospects of World Urbanization: Revised as of 1984-85 (New York, 1987), Table A-3, pp. 70-85.

8/ D. K. Walter, "Municipal Solid Waste Conversion," in D. O. Hall and R. P. Overend, eds., Biomass (New York, John Wiley, 1987), p. 189.

9/ Robert T. Glebs, "Landfill Costs Continue to Rise", Waste Age (March 1988), pp. 84-95.

10/ "Generating energy from urban and rural wastes in a selected country of the ESCWA region: the case of Egypt", Economic and Social Commission for Western Asia (E/ESCWA/NR/87/14).

11/ The General Assembly, at its forty-fourth session, adopted a resolution on the traffic in and disposal, control and transboundary movements of toxic and dangerous products and hazardous wastes (A/RES/44/226).

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IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION FOR THE DEVELOPMENT AND UTILIZATION OF NEW AND RENEWABLE SOURCES OF ENERGY

Progress achieved in resource mobilization, including consultative meetings, and inter-agency co-ordination

Report of the Secretary-General

SUMMARY

The present report reviews progress made in the mobilization of financial resources for the implementation of the Nairobi Programme of Action and provides information on the co-ordination of activities of the United Nations system, as requested by the Committee at its fourth session.

Section I discusses trends in the mobilization of financial resources, which indicate a decrease in the past two years. Recent global developments concerned with the environment may change the situation.

Section II discusses the co-ordination of United Nations activities in new and renewable sources of energy through the Inter-Agency Group on New and Renewable Sources of Energy of the Administrative Committee on Co-ordination and suggests that more effective co-ordination should aim at interaction with overall energy and associated environmental activities in the United Nations system.

* A/AC.218/1990/1.

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INTRODUCTION

1. The present report, dealing with the mobilization of financial resources and with inter-agency co-ordination within the United Nations system for the implementation of the Nairobi Programme of Action, has been prepared in response to requests made by the Committee at its fourth session. 1/

I. MOBILIZATION OF FINANCIAL RESOURCES

A. Background

2. The United Nations Conference on New and Renewable Sources of Energy adopted the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy. 2/ Implementation of the Nairobi Programme of Action involves numerous undertakings, including supporting actions, pre-investment activities and investment in projects and programmes. The successful completion of these undertakings requires considerable funds. The mobilization of financial resources is therefore of critical importance.

3. The Conference concluded that the implementation of the Nairobi Programme of Action required the mobilization of additional and adequate resources; each country would continue to bear the main responsibility for the development of its new and renewable sources of energy, which would require a fuller mobilization of its domestic financial and other resources; additional and adequate international financing resources, both public and private, from all developed countries, international financial institutions and other international organizations, would also be required; the Conference stressed that efforts should be made to increase concessional flows allocated to the financing of projects and programmes in the field of new and renewable sources of energy in developing countries in accordance with their national plans and priorities. 3/

4. In order to generate additional resources for the development and use of new and renewable sources of energy, the Conference recommended that consultative meetings should be convened to review and facilitate concerted action in this field; the consultative meetings should address the priority areas identified by the Nairobi Programme of Action. 4/

5. The Nairobi Programme of Action was endorsed by the General Assembly in resolution 36/193. In resolution 43/192, the Assembly reiterated the need to pursue actively ways and means of mobilizing adequate additional financial resources commensurate with the needs of developing countries in the field of new and renewable sources of energy and emphasized the need to utilize existing channels fully, including the United Nations Trust Fund for New and Renewable Sources of Energy. In the same resolution, the Assembly reaffirmed the importance of increasing inter-agency co-operation within the United Nations system, as well as co-ordination of development activities for new and renewable sources of energy at all levels.

6. Since the conclusion of the fourth session of the Committee on the Development and Utilization of New and Renewable Sources of Energy, there have been no major developments in the mobilization of financial resources.

B. Trends in resource mobilization

7. Table 1 shows the commitment of resources for the projects for the development of new and renewable sources of energy executed by the United Nations system, including energy conservation and energy planning in developing countries, for the period 1980-1989. Resource commitments in the field of new and renewable sources of energy, energy planning and energy conservation, which may involve conventional as well as renewable sources of energy, amount to some $13.4 billion in the period from 1980 to 1989; conventional large-scale hydropower accounts for most of this total (about 67 per cent). Commitments for the remaining new and renewable sources of energy together amount to approximately $4.4 billion. As is shown in figure I, fuelwood accounts for 28 per cent, which is the largest share, followed in descending order by general new and renewable sources of energy, energy conservation, energy planning and geothermal energy. The lowest commitments were for ocean energy, including ocean thermal energy conversion, tidal and wave energy.

8. The trend of resource commitments of United Nations organizations over the past 10 years is shown in figure II. The most noteworthy feature of this trend is the decrease in commitments over the past two years.

9. Financial mechanisms and institutions within the United Nations system have continued to provide funding for supporting actions and investment activities related to the development of new and renewable sources of energy. Commitments channelled through the United Nations system were approximately $7.6 billion, most of which (60 per cent) went into conventional large-scale hydropower development. This figure includes funding through the United Nations system only; national contributions to projects are excluded. The remaining new and renewable sources of energy, including small-scale hydropower, accounted for $3.0 billion. Of this amount, as can be seen from figure III, the largest share (more than $0.8 billion) was committed for energy conservation, followed, in descending order, by fuelwood and charcoal, general new and renewable sources of energy and energy planning.

10. The World Bank has continued to fund the largest share of activities in the field of new and renewable sources of energy for supporting actions, pre-investment activities and capital investments. Of the amount funded through the United Nations system, the World Bank and the International Development Association (IDA) accounted for nearly $7.2 billion (about 95 per cent).

11. Of the general resources of UNDP, some $186 million have been allocated to activities for new and renewable sources of energy. Other funds managed by UNDP, which funded activities in the area of new and renewable sources of energy in the 1980s, included the United Nations Sudano-Sahelian Office, the United Nations Capital Development Fund, the United Nations Special Industrial Services Programme, the United Nations Fund for Science and Technology for Development, the United Nations Development Fund for Women and the Energy Account of UNDP (see table 2).

12. Other organizations within the United Nations system have received funds-in-trust for specific projects in the field of new and renewable sources of energy. During the 1980s, a total of about $47 million was made available in this way.

13. The United Nations Trust Fund for the Development and Utilization of New and Renewable Sources of Energy, which was established in 1982, within the Office of the Director-General for Development and International Economic Co-operation, has received a total of approximately $2.5 million. A variety of activities related to new and renewable sources of energy have been funded through this Fund during the 1980s, including both global and regional consultative meetings, two small projects on reforestation in the Sudan and a more efficient metal stove in Kenya. Attached to this fund is an allocation to support activities related to prefeasibility studies on the proposals contained in the conclusions and recommendations of the Castel Gandolfo Colloquium of High-level Experts on New and Renewable Sources of Energy held in 1987.

C. Specific mechanisms for resource mobilization

1. Consultative meetings

14. Although the Committee has emphasized the importance of consultative meetings as a flexible mechanism for bringing together potential donors, recipients and interested organizations within and outside the United Nations system and as a mechanism for the mobilization of additional resources, no meetings have been held since the fourth session of the Committee.

2. Energy Account of the United Nations Development Programme

15. The Committee, at its second session, recommended that the Governing Council of UNDP should review the interim arrangements for the Energy Account to ensure that it operated on a more stable basis and to strengthen its activities in the field of new and renewable sources of energy. 5/ The Committee, at its third session, endorsed the need to strengthen the Energy Account of UNDP and invited the Governing Council to intensify its efforts to attract additional voluntary contributions. 6/ At its fourth session (March/April 1988), the Committee stressed the importance of an effective utilization of financial resources that had already been mobilized; and called for additional financial resources, to be mobilized through the existing financial mechanisms within the United Nations system, including the United Nations Trust Fund for New and Renewable Sources of Energy and the Energy Account of UNDP, 7/ in order to meet the needs of developing countries in the field of new and renewable sources of energy.

16. The Energy Account is the channel for contributions to energy activities, including renewable energy projects, co-financed by the various donor countries, the Organization of the Petroleum Exporting Countries and the UNDP/World Bank Energy Sector Management Assistance Programme. Based on a review of the resource situation, the Administrator of UNDP proposed to the Governing Council at its

thirty-fifth session (June/July 1988) that the Energy Office be closed and that its responsibilities be transferred to the United Nations Fund for Science and Technology for Development (DP/1988/47, para. 15).

17. Accordingly, by decision 88/39 of 1 July 1988, the Governing Council of UNDP decided "to close the Energy Office; while the Energy Account will remain, becoming a separate sub-account of the United Nations Fund for Science and Technology for Development in order to receive contributions for energy sector activities, which will be administered by the Fund". 8/ Although funding for core activities has not been forthcoming, the Fund has, over the past year, formulated a number of renewable energy projects for developing countries, using already existing trust-fund arrangements. Several of these initiatives have already helped to secure additional funding from other donors. For the future, the main thrust of the Energy Account will be to identify, formulate and fund energy projects on a co-financing basis with both bilateral and multilateral donors.

18. The Investment Development Office of UNDP may provide funding for pre-investment activities in the field of new and renewable sources of energy, which would promote further investment projects in developing countries in both the private and public sectors.

3. Other mechanisms for resource mobilization

19. Although the suggestion made by the Committee at its third session (A/AC.218/10, para. 65) and reiterated at its fourth session (A/AC.218/16, para. 18) that vigorous efforts geared to attracting funding from private sources should be pursued, other mechanisms have not materialized, with the exception of the Multilateral Investment Guarantee Agency (MIGA) of the World Bank. MIGA, which aims at encouraging or reviving direct investment in developing countries, has now become operational. Energy, including new and renewable sources of energy, is a prime area that may benefit from this new mechanism for resource mobilization.

D. Conclusions

20. Much more needs to be done for the mobilization of financial resources in order to meet the objectives of the Nairobi Programme of Action.

21. In recent years, lower energy prices and a widespread perception of abundant supplies of conventional sources of energy including nuclear power have led to a significant decline of both public and private sector involvement in new and renewable sources of energy with consequent reductions in public spending for research, development and demonstration projects and private investment.

22. In the developed market economies, public sector support for research and demonstration through budget allocations and subsidies in the early 1980s has been scaled down. Similarly, private corporations have reduced their involvement and investments.

23. At the bilateral and multilateral levels, reduced overall allocations in the face of increasing needs and priorities have also resulted in fewer activities in the field of new and renewable sources of energy.

24. In the developing world, the economic crisis in Africa and Latin America has had similar effects as far as new and renewable sources of energy are concerned. In Asia, however, significant progress has been achieved, particularly, in China and India.

25. More recently there has been a marked change in perceptions of the global energy situation and prospects. A tightening in energy markets and a stabilization of energy prices are indicated. At the same time, increasing concern about the environmental effects of expanded development and use of conventional energy sources has led to a revival of interest in new and renewable sources. However, these concerns have not yet been translated into greater financial commitments. In fact, energy projections to the year 2000 and beyond generally show continued reliance on conventional sources of energy, including subsidies for environmentally unsound sources in some national energy markets, together with insignificant increases in the contributions of new and renewable sources.

26. The delay in anticipated technological breakthroughs and the lack of progress in the transfer of existing technologies and their adaptation to social conditions in the developing countries have also contributed to the malaise.

27. The promise of additional financial resources through consultative meetings, which can bring together potential donors, developing countries and agencies, has been disappointing. No consultative meetings have taken place since the fourth session of the Committee.

28. Similarly, resources made available through the UNDP Energy Account, which has now become a subsidiary account of the United Nations Fund for Science and Technology for Development, and the United Nations Trust Fund for the Development and Utilization of New and Renewable Sources of Energy, have remained at very low levels.

29. Increasing concern in the international community about the environmental effects of conventional energy development and use and increasing realization that the economic advance of developing countries will inevitably require more energy have already led to a radical reassessment of policies, in at least some of the countries having developed market economies. The Governments of those countries have also expressed their readiness to consider new measures and policies to assist developing countries in developing and using environmentally benign sources of energy, including new and renewable sources.

30. In view of the emerging coalescence of interests between the developing countries and the developed market economies, the Committee may wish to consider ways and means of facilitating and expediting the process with the aim of promoting effective international co-operation in the accelerated development and utilization of new and renewable sources of energy.

II. INTER-AGENCY CO-ORDINATION

A. Background

31. The Nairobi Programme of Action recommended that the Director-General for Development and International Economic Co-operation should be entrusted with the task of co-ordinating the contributions of the organs and organizations of the United Nations system in the implementation of the Nairobi Programme of Action. 9/ The General Assembly, in resolution 37/250, section V, requested the Director-General to convene an ad hoc inter-agency meeting in order to establish an ad hoc inter-agency group and to define its terms of reference. The Inter-Agency Group on New and Renewable Sources of Energy was established in February 1983.

32. In resolution 37/250, section III, the General Assembly decided on secretariat support arrangements, including the appointment of a special co-ordinator in the Office of the Director-General and the establishment of a unit in the Department of International Economic and Social Affairs entrusted, inter alia, with the task of serving as a focal point for information on multilateral, bilateral and other activities in the area of new and renewable sources of energy. At its fourth session, the Committee again emphasized the importance of effective co-ordination within the United Nations system for the implementation of the Nairobi Programme of Action and called upon the Inter-Agency Group to intensify its efforts for enhanced co-ordination of activities within the United Nations system. 10/

B. Activities of the Inter-Agency Group on New and Renewable Sources of Energy

33. Since its establishment, the Inter-Agency Group on New and Renewable Sources of Energy has held eight sessions, with the participation of interested organizations of the United Nations system.

34. Subsequent to the fourth session of the Committee, the Inter-Agency Group met in March 1989. At that meeting, the Group was briefed on the discussions and decisions of the Committee. The Group considered activities to be undertaken in preparation of the Committee's fifth session, including the collection of information on ongoing and planned activities in the field of new and renewable sources of energy.

35. The Inter-Agency Group agreed that detailed presentation and ensuing discussion of the current and planned activities by individual entities were of crucial importance and would lead to the identification of activities that might merit further co-operation and co-ordination and to the elaboration of conceptual issues that might enhance the development and use of new and renewable sources of energy.

36. The Inter-Agency Group affirmed the need to evaluate new and renewable sources of energy in relation to the environment and sustainable development, and decided to submit a report, for consideration by the Committee at its fifth session, on environmental issues and impacts associated with the development of new and

renewable sources of energy. The report, the first such collaborative effort of the Group, is contained in the annex to document A/AC.218/1990/3

37. The Inter-Agency Group agreed that women's needs should be given particular consideration and their full participation assured in the planning and implementation of projects in new and renewable sources of energy and in the development of technologies in these areas.

38. The Inter-Agency Group was informed of the activities in follow-up of the Castel Gandolfo Colloquium of High-level Experts on New and Renewable Sources of Energy. The Director-General for Development and International Economic Co-operation had established a Consultative Group of High-level Experts to provide guidance and advice on substantive matters relating to the follow-up of the Colloquium. The first meeting of the Consultative Group took place at Rome, in April 1989. As part of the preparation of the Rome meeting, visits were planned to three centres of the Consultative Group on International Agricultural Research (CGIAR), one each in Africa, Asia and Latin America, in order to obtain on-the-spot information on their experience. It was agreed that the Inter-Agency Group should be kept informed of the activities of the Consultative Group and would provide appropriate inputs as requested and co-operate in the implementation of the recommendations of the Colloquium of High-level Experts.

39. An important long-term objective of the Inter-Agency Group is to avoid duplication and overlapping of activities. The meetings of the Group provide participants with an opportunity for recurrent direct contacts and exchange of views. This facilitates communication among officers responsible for new and renewable sources of energy programmes in their respective organizations and contributes to improved co-ordination within the United Nations system. The Group discussed measures to improve and enhance the effectiveness of the functioning of its meetings.

40. In conclusion, inter-agency co-ordination continues to be essential to the effective and efficient implementation of the Nairobi Programme of Action within the United Nations system. In the past, exchange of information among members of the Inter-Agency Group has contributed to avoidance of duplication and overlap but more needs to be done, particularly in the co-ordination of plans. Similarly, more effective co-ordination should aim at interaction with overall energy and associated environmental activities in the United Nations system.

Notes

1/ Official Records of the General Assembly, Forty-third Session, Supplement No. 36 (A/43/36), para. 72.

2/ Report of the United Nations Conference on New and Renewable Sources of Energy, Nairobi, 10-21 August 1981 (United Nations publication, Sales No. E.81.I.24), chap. I, sect. A.

3/ Ibid., para 76.

Notes (continued)

4/ Ibid., para 91.

5/ Ibid., Thirty-ninth Session, Supplement No. 44 (A/39/44), para. 74 (c).

6/ Ibid., Forty-first Session, Supplement No. 44 (A/41/44), annex, sect. A, resolution 2 (III), para. 9.

7/ Ibid., Forty-third Session, Supplement No. 36 (A/43/36), para. 72.

8/ Official Records of the Economic and Social Council, 1988, Supplement No. 9 (E/1988/19), annex I.

9/ Report of the United Nations Conference on New and Renewable Sources of Energy ..., chap. I, sect. A, para. 63.

10/ Official Records of the General Assembly, Forty-third Session, Supplement No. 36 (A/43/36), para. 72.

Table 1. Resource commitments executed by entities within the United Nations system, 1980-1989

(Millions of United States dollars)

	ALCOHOL	ANIMAL	BIOGAS	BIOMASS	FUELWOOD CHARCOAL	CONHYDRO a/	CONSERVE	MINHYDRO GENERAL	GEOTHER	MINHYDRO b/	OILSHALE	OCEAN	PEAT	PLANNING	SOLAR	VOLTAIC	WIND	TOTAL
DIEC	..	..	..	..	..	..	..	0.6	..	..	..	..	..	..	..	..	..	0.6
DIESA	..	..	..	..	0.0	..	0.4	3.5	..	..	..	..	..	1.5	..	0.1	..	5.5
DTCD	..	..	0.9	0.0	0.1	7.7	5.4	6.7	48.1	27.6	0.3	0.3	0.1	39.5	5.9	3.3	3.5	150.4
FAO	0.2	5.7	2.9	4.7	89.6	0.1	3.8	7.2	0.1	0.1	..	..	..	6.8	2.0	..	1.6	124.8
IBRD	..	..	42.8	2.4	512.6	6,081.3	744.2	844.9	145.5	25.6	20.0	..	..	320.1	3.7	..	2.7	10,746.9
IDA	32.6	1.1	..	38.3	722.5	898.6	121.3	212.6	54.4	..	..	..	..	87.0	..	..	..	2,166.5
ILO	..	0.1	0.0	0.0	0.4	0.0	1.3	1.8	0.0	0.0	..	..	..	3.8	0.1	..	0.0	7.5
REG COMM	0.3	..	0.7	2.0	1.4	0.3	2.0	16.4	0.1	2.0	0.1	..	0.2	7.7	2.5	1.6	1.6	38.9
UNCHS	..	..	0.1	0.1	..	..	0.1	0.9	..	..	..	..	..	0.5	0.4	..	0.1	2.3
UNDP	..	0.0	7.2	0.4	11.0	5.7	2.5	4.4	0.6	6.5	1.1	0.0	2.0	5.6	0.2	0.1	6.1	55.6
UNEP	..	..	0.1	0.4	0.5	..	0.1	0.4	..	0.1	..	..	..	0.5	0.3	0.2	0.3	2.8
UNESCO	..	..	0.6	2.5	1.2	0.0	0.3	11.9	0.6	0.0	..	..	..	0.4	5.0	..	0.1	23.0
UNICEF	..	..	0.4	0.1	0.6	..	..	0.2	..	0.1	..	..	..	..	0.3	..	0.2	2.0
UNIDO	1.7	..	2.5	11.0	2.6	1.9	9.1	7.5	..	3.6	..	..	0.6	6.1	6.2	2.4	2.3	57.7
UNITAR	..	..	..	..	..	..	..	0.5	0.3	..	0.2	..	..	..	0.0	0.0	..	1.1
UNU	..	..	0.2	0.2	..	..	..	0.6	1.9	..	..	..	..	1.5	0.2	..	0.2	4.7
WMO	..	..	..	..	..	0.7	..	0.1	..	0.0	..	..	..	0.1	0.9	..	0.9	2.8
OTHERS*	..	..	..	0.1	..	0.1	0.0	0.4	0.0	0.1	..	..	..	0.1	0.5	..	0.0	1.3
TOTAL	34.8	6.9	56.2	63.4	1,342.7	6,996.4	891.5	1,120.6	251.9	67.9	21.7	0.3	2.9	481.2	26.2	7.7	19.6	13,396.4

Note

DIEC: Office of the Director-General for Development and International Economic Co-operation; DIESA: Department of International Economic and Social Affairs; DTCD: Department of Technical Co-operation for Development; FAO: Food and Agriculture Organization of the United Nations; IBRD: International Bank for Reconstruction and Development; IDA: International Development Association; ILO: International Labour Organisation; UNCHS: United Nations Centre for Human Settlements (Habitat); UNDP: United Nations Development Programme; UNEP: United Nations Environment Programme; UNESCO: United Nations Educational, Scientific and Cultural Organization; UNICEF: United Nations Children's Fund; UNIDO: United Nations Industrial Development Organization; UNITAR: United Nations Institute for Training and Research; UNU: United Nations University; WMO: World Meteorological Organization.

Other: Department of Political and Security Council Affairs; United Nations Centre on Transnational Corporations; Department of Conference Services; Centre for Science and Technology for Development; United Nations Conference on Trade and Development; United Nations Volunteers programme; International Research and Training Institute for the Advancement of Women; World Health Organization; Universal Postal Union; International Telecommunication Union; World Intellectual Property Organization; International Fund for Agricultural Development; International Atomic Energy Agency.

A zero indicates a value of less than $50,000.

a/ Hydropower more than 10 MW.

b/ Hydropower less than 10 MW.

Table 2. Major funding sources within the United Nations system, by energy source, 1980-1989

(Thousands of United States dollars)

ORGANIZATION	ALCOHOL	ANIMAL	BIOGAS	BIOMASS	FUELWOOD & CHARCOAL	CONHYDRO	CONSERVE	GENERAL	GEOTHERM
WORLD BANK									
IBRD	40.5	50.5	19,906.7	2,576.7	218,225.5	3,725,327.3	594,323.8	400,926.0	97,773.8
IDA	34,200.1	479.8	0.0	23,786.7	519,851.3	838,355.5	194,406.4	100,651.4	47,149.8
UNDP/IPF	1,460.4	2,905.7	3,960.8	6,305.4	28,478.5	22,660.4	9,927.4	14,911.6	26,207.4
UNCDF	0.0	0.0	0.0	0.0	919.6	2,752.0	0.0	171.8	0.0
UNDP/ENERGY A	0.0	0.0	78.3	979.7	403.0	585.0	960.9	507.1	1,056.5
SIS	42.3	0.0	75.5	220.9	162.2	0.0	69.9	28.6	0.0
FSTD	25.0	0.0	551.9	5,513.8	1,255.5	535.4	295.0	8,555.6	2,968.0
UNIFEM	0.0	0.0	0.0	0.0	333.2	0.0	22.7	0.0	0.0
UNSO	0.0	50.0	0.0	506.6	18,948.9	1,549.4	2,673.4	469.3	0.0
UNIDO	146.7	0.0	373.2	1,336.9	831.9	276.0	1,496.7	1,290.1	0.0
IDF	279.4	0.0	1,791.3	894.3	741.7	0.0	166.8	132.1	0.0
FIT	12.4	146.8	500.0	665.0	30,907.1	15.0	900.4	700.7	0.0
TOTALS	36,206.8	3,632.8	27,237.7	42,786.0	821,058.4	4,592,056.0	805,243.4	528,344.3	175,155.5

ORGANIZATION	MINHYDRO	OILSHALE & TARSANDS	OCEAN ENERGY	PEAT	PLANNING	SOLAR	VOLTAIC	WIND	TOTAL
WORLD BANK									
IBRD	12,207.9	20,000.0	0.0	100.8	308,645.6	2,196.0	0.0	2,121.0	5,404,422.1
IDA	0.0	0.0	0.0	0.0	67,743.5	0.0	0.0	0.0	1,826,624.5
UNDP/IPF	7,782.2	493.2	288.4	1,016.0	41,960.5	8,495.5	5,456.0	3,942.4	186,251.8
UNCDF	23,380.8	0.0	0.0	0.0	919.6	74.8	0.0	0.0	28,218.6
UNDP/ENERGY A	280.6	246.4	0.0	0.0	16,868.6	36.1	106.5	280.9	22,389.6
SIS	171.1	0.0	0.0	0.0	41.0	258.0	0.0	17.4	1,086.9
FSTD	0.0	0.0	0.0	0.0	3,670.5	1,513.5	1,414.5	867.4	27,166.1
UNIFEM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	355.9
UNSO	40.0	0.0	37.2	1,348.9	0.0	21.0	0.0	6,022.9	31,667.6
UNIDO	1,253.1	0.0	0.0	0.0	2,709.6	2,615.2	0.0	1,400.1	13,729.5
IDF	668.5	0.0	0.0	594.6	156.4	1,167.0	0.0	128.1	6,720.2
FIT	15.0	0.0	0.0	67.2	2,102.5	744.7	0.0	132.7	36,909.5
TOTAL	45,799.2	20,739.6	325.6	3,127.5	444,817.8	17,121.8	6,977.0	14,912.9	7,585,542.3

Note

IBRD: International Bank for Reconstruction and Development; IDA: International Development Association; UNDP/IPF: indicative planning figure resources of UNDP; UNCDF: United Nations Capital Development Fund; UNDP/E: Energy Account of UNDP; SIS: Special Industrial Services Programme; UNFSTD: United Nations Fund for Science and Technology for Development; UNIFEM: United Nations Development Fund for Women; UNSO: United Nations Sudano-Sahelian Office; UNIDO: United Nations Industrial Development Organization; IDF: Industrial Development Fund; FIT: funds-in-trust for the use of the United Nations.

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Figure I. Resource commitments executed by the United Nations system, 1980-1989

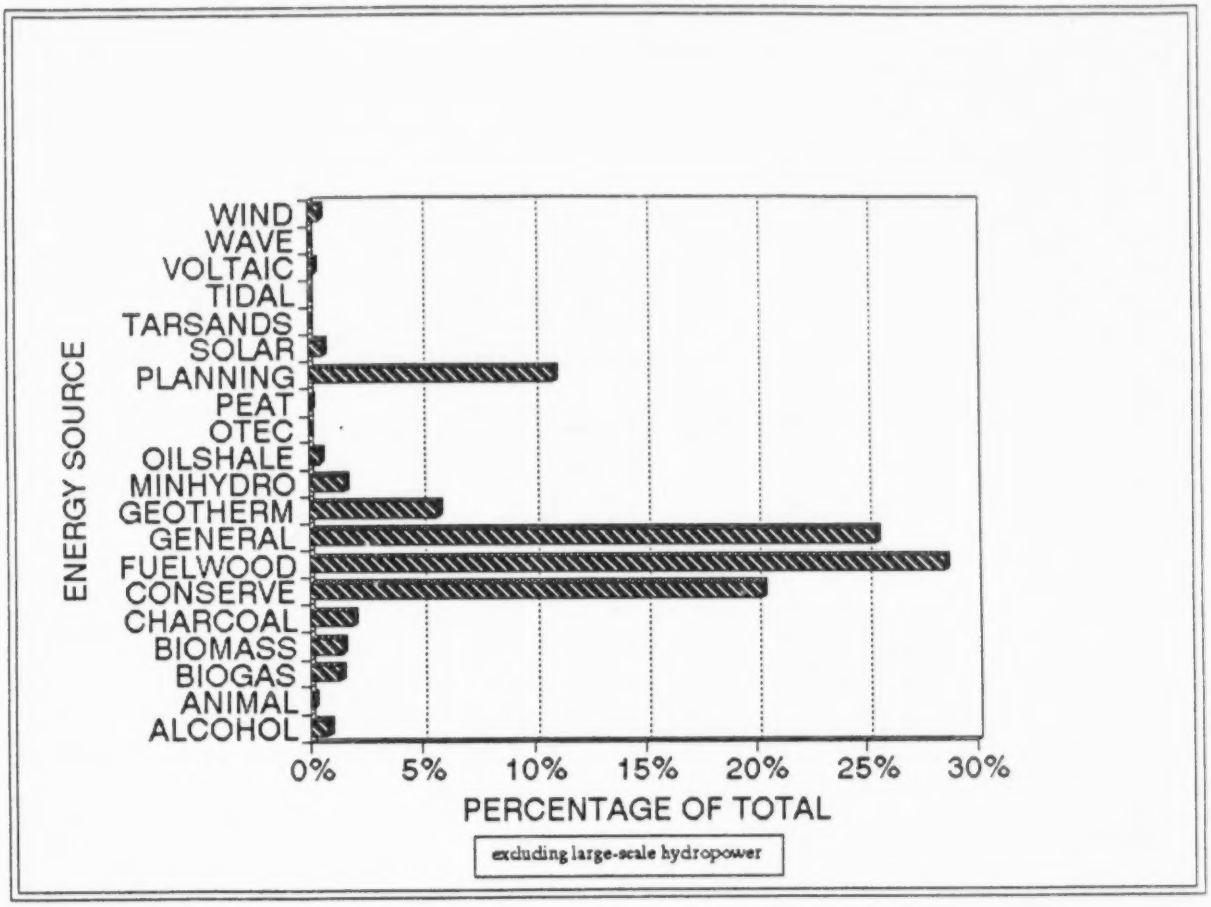


Figure II. Annual resource commitments by the United Nations system, 1980-1989

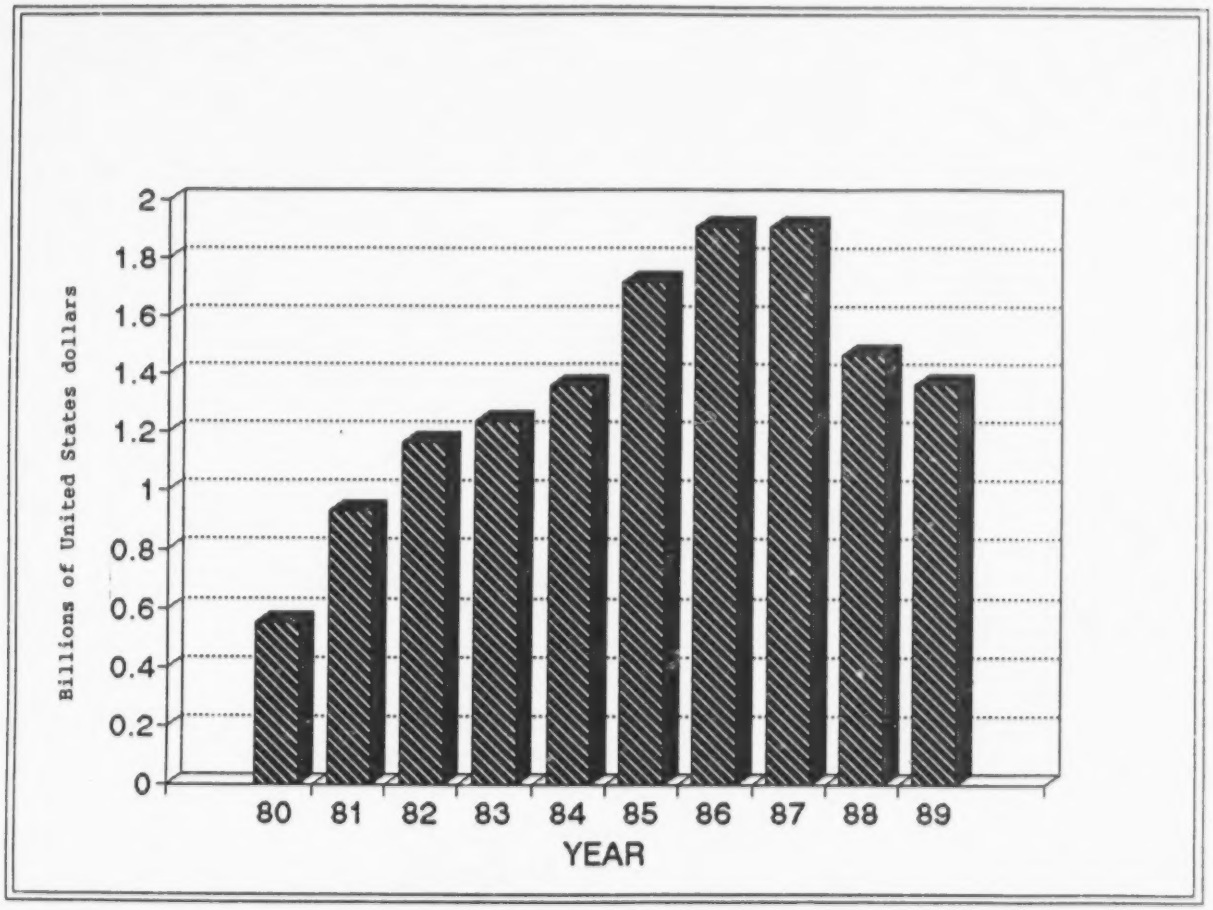
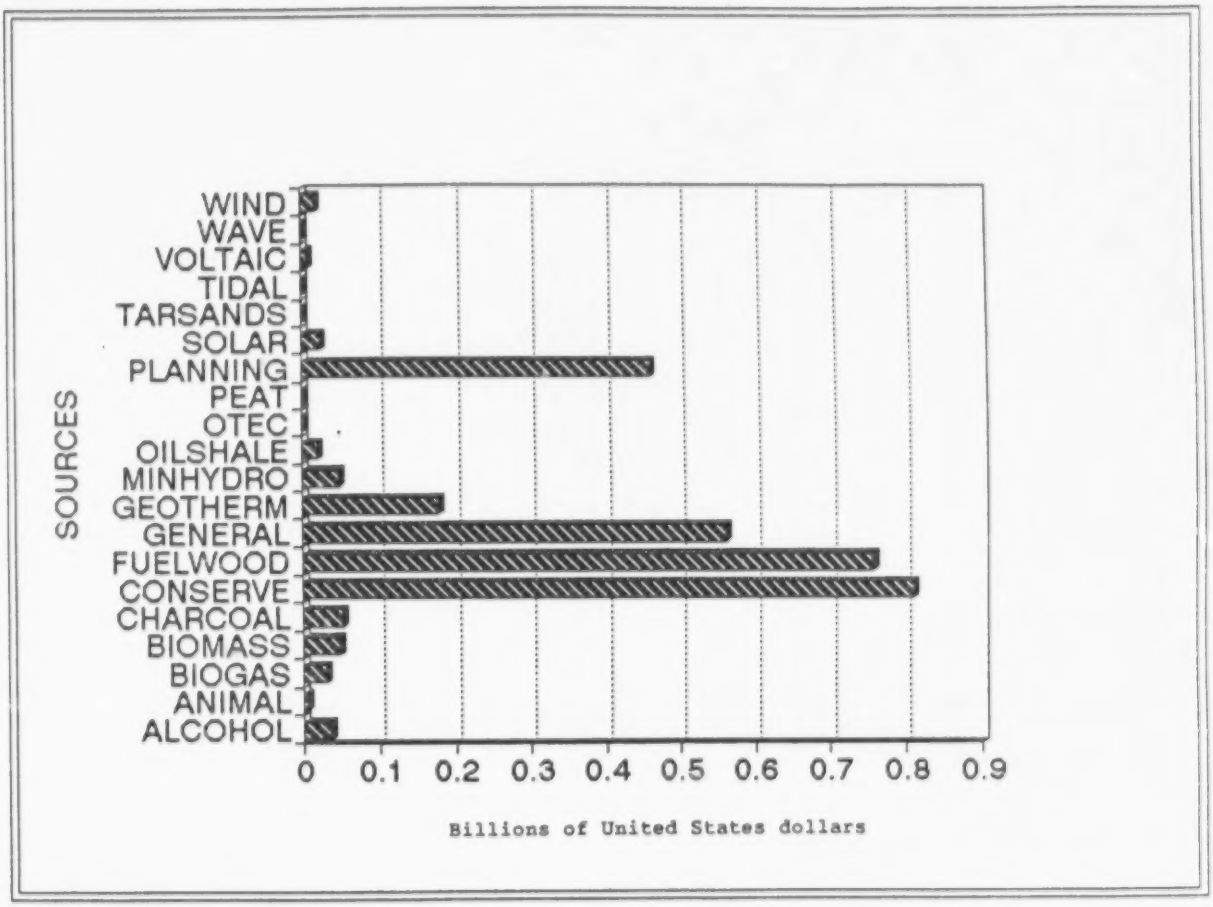


Figure III. Contributions by the United Nations system, by energy source, 1980-1989



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COMMITTEE ON THE DEVELOPMENT AND
UTILIZATION OF NEW AND RENEWABLE
SOURCES OF ENERGY
Fifth session
26 March-4 April 1990
Item 4 of the provisional agenda*

IMPLEMENTATION OF THE NAIROBI PROGRAMME OF ACTION FOR THE DEVELOPMENT AND UTILIZATION OF NEW AND RENEWABLE SOURCES OF ENERGY

Project proposals of entities within the United Nations system and the status of their implementation

Report of the Secretary-General

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* A/AC.218/1990/1.

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INTRODUCTION

1. At its fourth session in 1988, the Committee on the Development and Utilization of New and Renewable Sources of Energy requested the Secretary-General to report to it at its subsequent sessions on progress achieved in the implementation of programmes and projects in new and renewable sources of energy by entities within the United Nations system. 1/

2. Since a previous report on this subject, submitted to the Committee at its third session (A/AC.218/11), covered the period up to and including 1985, the present report summarizes programmes and projects for the period 1986-1989, on the basis of categories contained in the report of the Administrative Committee on Co-ordination (ACC) to the Interim Committee on New and Renewable Sources of Energy in 1982 (A/AC.215/5).

I. PROJECTS AND PROGRAMMES ON NEW AND RENEWABLE SOURCES OF ENERGY, 1986-1989

3. The descriptions below of projects and programmes proposed and carried out by the United Nations system on new and renewable sources of energy is based on data reported to the Secretariat by entities within the United Nations system. Due to space constraints, the report cannot go into detail. For more comprehensive descriptions, reference may be made to the compendium of activities of the United Nations system in new and renewable sources of energy, which is available, upon request, from the New and Renewable Sources of Energy Unit, Energy and Resources Branch, Department of International Economic and Social Affairs.

A. Energy assessment and planning

4. Assessment, planning and energy statistics projects and programmes are described in paragraphs 5-22 below. Resource evaluation and exploration requirements are covered in subsection B.

1. Assessment

5. The Department of International Economic and Social Affairs (DIESA) is involved in global energy analysis, including the monitoring of overall trends in new and renewable sources of energy in its reports to the Committee on Natural Resources, the Economic and Social Council and the General Assembly.

6. The Department of Technical Co-operation for Development (DTCD) had two programmes providing criteria and methodologies for selecting energy technologies, one for small energy systems in isolated communities, mainly involving new and renewable sources of energy, and another for small hydropower.

7. The Economic Commission for Latin America and the Caribbean (ECLAC) surveyed and assessed the situation for new and renewable sources of energy in six Central American countries.

8. The Economic and Social Commission for Asia and the Pacific (ESCAP) has ongoing programmes assessing the regional energy situation and economy, including new and renewable sources of energy and integrated planning, particularly in rural areas.

9. The Economic and Social Commission for Western Asia (ESCWA) has an ongoing programme on the assessment and surveying of energy-related activities in the region. It includes a review of new and renewable sources of energy.

2. Planning

10. In India DTCD has provided help in long-range electricity generation planning through the modernization of the institutional infrastructure and the supply of planning software. It also had a programme in the application of microcomputers and software for energy planning appropriate for developing countries in general. Assistance has been given to the National Energy Board of Ghana to develop energy planning and management skills.

11. The Economic Commission for Africa (ECA) provides advisory services on energy planning and policy formulation to African countries.

12. ECLAC has two programmes in planning. One analyses energy price policies in relation to fuel substitution and demand management. The other involves the energy planning, analysis and outlook in Central America.

13. ESCAP has a programme on strengthening regional capabilities for integrated national energy planning and programming. The third phase of its regional energy development programme, which provides training in energy planning and the use of microcomputers, is in process.

14. The World Bank has had a planning and conservation project in Cyprus. It included setting up an energy data bank and an applied renewable energy centre, initiating a solar and wind measurement network and providing guidance in electricity conservation management. The Bank is also involved in a project in Jordan which includes new and renewable sources in energy planning. There is a joint European/Arab project sponsored by the Bank and the United Nations Development Programme (UNDP) on energy investment planning systems. In Malawi the Bank has a project on energy sector planning and management.

15. Under the Energy Sector Management Assistance Programme (ESMAP), a joint undertaking of the World Bank and UNDP, with special support from donor countries, about 50 developing countries have been helped in energy planning, with particular reference to new and renewable sources of energy for the household and rural sectors.

16. The International Development Association provided assistance to Niger on power development planning, including the organization and management of the power sector. The International Labour Organisation (ILO) has been providing assistance to national and local agencies responsible for planning and implementation of energy projects and programmes within its own technology policies and institutions programme. UNDP executed energy planning projects both in Vanuatu and Kiribati.

17. The United Nations Industrial Development Organization (UNIDO) provided assistance to Mexico on the planning of local manufacturing of energy equipment. It also provided assistance to Niger in the strengthening of the Ministry of Mines and Energy.

18. The United Nations University (UNU) has a programme on energy planning and management which studies energy planning in developing countries and develops training programmes for decision makers, engineers and technicians and conducts research on specific problems in energy planning.

3. Energy statistics

19. DIESA has been developing concepts, classifications and methods in new and renewable sources of energy statistics and also collects, compiles and disseminates energy-related statistics. It publishes the annual Energy Statistics Yearbook and the Energy Balances and Electricity Profiles. A handbook for statistical programmes for household and small-scale industry has been published.

20. DTCD assisted Egypt in establishing an energy statistical data base for planning in the electricity sector. ECA collects industrial and energy statistics for Africa and also provides training in their collection, compilation and dissemination to African statistical institutions.

21. The Economic Commission for Europe (ECE) publishes general energy statistics in bulletins covering Europe and North America. ECLAC has been promoting the usefulness of time-series analysis of some key energy trends to Governments in order to assist them in energy planning. ECLAC produces its own statistics on energy production, resources, trade and consumption in the region, mainly geared towards governmental users. And ESCAP provides advice and training on energy statistics.

22. The Food and Agriculture Organization of the United Nations (FAO) provides basic statistical information on forest energy and also organizes training and workshops in the planning of fuelwood production.

B. Evaluation, and research, development and demonstration

23. Resource evaluation activities include exploration, resources assessment and supply measurement projects and programmes. Research, development and demonstration was a theme for in-depth consideration by the Committee at its fourth session in 1988 (see A/AC.218/13). Its two aspects - reseach and development, and demonstration of proved technologies - are discussed separately below.

1. Resource evaluation

24. DTCD is evaluating windpower resources in Mauritius as part of introducing the technology to that country. In Bolivia an assessment of geothermal resources in the Laguna Colorada area has taken place, including some exploration drilling. In Iraq an assessment of solar energy resources is ongoing, with the objective of evaluating the potential for thermal processes. In Pakistan DTCD is assessing the agricultural crop residue supply and the possibility of using it for energy production. DTCD also had a global programme on evaluating small-scale hydropower resources for isolated communities. Geothermal resources are being explored in Bolivia, China, Honduras, Kenya and Yugoslavia.

25. ECA has been evaluating energy resources as part of a programme which aims at integrating energy policy into overall socio-economic policy planning. ECA is also in the process of establishing an African Centre of Meteorological Application for Development, which will be involved in solar and wind resource measurement. ESCAP completed a microhydropower survey of priority areas in the region in 1988. ESCWA published the proceedings from a seminar held in Jordan where the region's solar and wind resources were assessed and presented a paper at the Fourth Arab Energy Conference in 1988, evaluating available new and renewable sources of energy resources in the region. The prospects and resource supply for using biogas in the ESCWA region have also been evaluated. One of the regional programmes of ESCWA is a review of new and renewable energy resources and technologies applicable to the area. The actual use of the resources is also surveyed under the programme.

26. The World Bank has been involved in the promotion of geothermal exploration in Ethiopia and the development of an energy data base in Costa Rica to establish national resource evaluation and planning capabilities. The World Bank is also involved in a global wind evaluation programme which is funded by UNDP.

27. The International Development Association (IDA) is involved in acquiring seismic data to be used in geothermal exploration in Ethiopia. It is also assisting in the promotion of geothermal energy exploration in Kenya, including well drilling. Meanwhile, UNDP has completed its activities in wind energy assessment in Cape Verde.

28. The United Nations Educational, Scientific and Cultural Organization (UNESCO) is involved in a global programme to develop methodologies for water resources assessment, which will include potential water resources for hydropower. UNIDO has been estimating the bagasse and wood waste available in 1987-2000 in Fiji as part of a feasibility study on the potential for generating energy from biomass on the island.

2. Research and development

29. DTCD is developing (and demonstrating) prototypes of primarily photovoltaic and wind/diesel technologies in Egypt. Assistance is being given to Afghanistan for the establishment of a research and development centre in new and renewable sources of energy, with emphasis on solar energy technologies. Assisted by DTCD,

Mongolia is the site of applied research and development of new and renewable sources of energy for rural use, mainly involving wind, solar and biogas. Assistance is being given to Cape Verde for strengthening technical research capabilities at the National Institute for Technical Research, especially in relation to solar and wind technologies. In Yugoslavia assistance is being given to solar/thermal research and development. In Peru DTCD is establishing a polysilicon laboratory to develop processes using domestic quartz sand. The second phase of assistance in the development of new and renewable sources of energy technologies at the New Energy Sources Laboratory in Bucharest, Romania, was initiated in 1989. The research will emphasize photovoltaic and hybrid photovoltaic/wind systems.

30. ESCAP has an ongoing programme of co-operative research on and development of new and renewable sources of energy. It publishes technical literature and gives technical assistance, with the aim of strengthening national research capabilities. FAO supports the Asian Association of Agricultural Research Institutions and other networks involved in research on biomass, biogas and other new and renewable sources of energy. FAO is involved in the development of solar dryer systems for agricultural products in Africa.

31. UNIDO supports the research activities of the National Chemistry Laboratory in Biotechnology in India in fermentation of biomass. Another project involving alcohol production from biomass receives support in Brazil. India also receives support in its research on silicon technology for use in photovoltaic cells. UNIDO will continue research into new and renewable sources of energy in Madagascar and Paraguay, which may lead eventually to demonstration projects.

32. UNU has a programme of research in energy planning, management and technology assessment. It also supports the establishment of a network of research centres on new and renewable sources of energy, with funding from Italy.

3. Demonstration of proved technologies

33. DTCD is assisting Pakistan in the demonstration of renewable technologies for use in rural areas. It is also assisting the Maldives in small energy packages suitable for small islands. ESCAP has an ongoing regional project for the demonstration of solar drying and cooling of grain in bulk storage and has established a regional network on biomass, solar and wind energy aimed at enhancing research, development and demonstration activities in the region.

34. FAO is involved in demonstration projects for gasifiers and steam engines as part of its programme of wood energy conversion systems. It also supports several agroforestry demonstration projects related to increasing fuelwood resources, including projects in Senegal and Nepal. The World Bank has a global programme for monitoring the demonstration of biogas technologies. The United Nations Environment Programme (UNEP) is involved in the establishment of a network on renewable energy in Africa in order to demonstrate energy technologies that are considered environmentally sound.

35. UNIDO completed its demonstration of the use of solar energy for salt production in Kiribati and Nigeria. It has long-standing involvement in the demonstration of biogas technologies in China. It is also testing agricultural waste gasifiers in Africa. In the Sudan and Uruguay UNIDO is demonstrating charcoal manufacturing, and in Senegal and Ethiopia, the use of biogas technology. UNIDO is also demonstrating solar/thermal applications in Jamaica and Sierra Leone.

C. Integrated rural energy development

1. Increasing food and agricultural production

36. FAO is responsible within the United Nations system for the development of draught animal power and has implemented several global projects as well as national projects in Benin, Niger, Somalia, and Togo. FAO has assisted countries in the development and use of improved agricultural equipment to maximize the utilization of available energy sources; in the development of integrated farm systems, including the training of farmers on solar drying methods to reduce harvest losses; and in water management, using energy-saving devices.

37. UNIDO has implemented a project on the utilization of agricultural wastes for energy for irrigation pumps in rural areas. UNIDO has also undertaken projects on the use of solar energy to dry fruits and vegetables. The World Bank has provided funding for a hydro-electric station of 600 MW which will also provide water for irrigation in India. UNEP provided assistance to develop further a rural energy centre in Sri Lanka.

2. Meeting the fuelwood needs of rural households

38. DTCD undertook a feasibility study on making briquettes for energy purposes from agricultural crop residues. Meanwhile ECE has made assessments of methods and equipment for harvesting wood for energy purposes. ESCAP has implemented projects to develop and disseminate improved cooking stoves. ECLAC has provided studies on new and renewable sources of energy in Central America and considered firewood for special attention as an energy source.

39. FAO has many ongoing projects on charcoal development and the use of wood fuels in rural industries, involving the more efficient wood energy conversion devices as well as forestry resources development. FAO has also conducted projects on improved policies for the conservation and development of fuelwood resources and the use of wood-processing residues for energy, and has provided assistance to applications of solar energy for agriculture industries.

40. UNESCO assisted in the development of solar and biogas production to furnish energy for cooking and other applications. UNIDO has undertaken a field test programme for the production of charcoal from agricultural wastes, which included employment and income-generation for women and the provision of fuel for domestic use, and has investigated the use of minihydro plants in rural areas, so as to conserve forest resources. ILO has implemented projects on forestry and wood

industries. Both the World Bank and IDA have undertaken projects on forest plantations to provide fuelwood in a number of countries. UNDP has undertaken projects on briquette production and improved cooking stoves for household use.

3. Promoting small-scale agro-industry

41. ESCWA has supported activities involving the use of solar and wind energy for pumping, desalination and ice-making and a solar agro-industrial demonstration farm. Additional projects have dealt with biogas technologies. ESCWA has also undertaken a regional project on generating energy from urban and rural waste. ECE has supported long-term projects on the use of new and renewable sources of energy in agriculture.

42. FAO has supported projects on the use of wood fuels, biomass and solar drying in rural industries and village applications as well as training in the utilization of agricultural residues. UNIDO has provided assistance to developing countries in applications of new and renewable sources of energy to rural and remote industries, including biomass converters, solar energy, small-scale hydro power, agricultural wastes, small-scale charcoal manufacture, solar energy for salt production, and biogas technology. Several projects have focused on the role of women and have included applications of solar energy in drying fruits and vegetables and in salt production. FAO has provided assistance in the use of diverse agricultural materials in fuel-alcohol programmes.

43. UNIDO has also provided advice on energy conservation and energy substitution in industry, including the use of agricultural wastes. Assistance was also provided to countries in Asia and the Pacific, the Caribbean and Africa on the utilization of indigenous agricultural biomass resources, such as bagasse and biogas, for rural applications.

44. The World Bank undertook a pilot project to improve fuelwood use in the tobacco-curing industry. UNDP has implemented projects using wood-fuelled generators for rural electrification.

4. Integrating rural energy systems

45. DTCD has undertaken since 1987 a number of integrated rural energy projects, including an ongoing project on applied research and development for the rural use of renewable energy, designed to investigate and test various types of equipment using new and renewable sources of energy, such as small wind generators and biogas digesters. A long-term project focused on the development of small-scale systems, including solar energy, photovoltaic units, gasifiers and wind energy. In 1989, DTCD initiated a project in the ECLAC region focusing on energy conservation and training in integrated energy planning. The two latter projects were undertaken with funds from UNDP.

46. ESCWA has undertaken a number of projects to identify and promote new and renewable sources of energy suitable to the region. They have included

applications of solar, wind, biomass and minihydro technologies to rural and remote areas. ECE has undertaken studies of the use of new and renewable sources of energy in agriculture, including the use of heat pumps.

47. FAO has ongoing projects in energy planning and training for the assessment of rural energy systems. Other FAO projects have included research on co-operative networks on rural energies focusing on biomass and fuelwood. The World Bank has supported activities in agriculture and livestock development, which have included pilot biogas plants and studies of geothermal water development.

48. UNU has supported the Integrated Rural Energy Systems Association, which has carried out a series of demonstration pilot and survey projects and training programmes for decision makers, engineers and technicians in energy planning in rural areas.

49. For further discussion of the activities within the United Nations system relating to the role of new and renewable sources of energy in integrated rural development, see the report of the Secretary-General on that subject (A/AC.218/1990/4).

D. Energy and industrialization

50. The projects described below involve energy for industries other than agro-industry.

1. Hydropower

51. The cost of projects executed by United Nations entities involving large-scale hydropower construction and development amounted to some $US 4.3 billion during 1986-1989. That represents about 66 per cent of the value of all projects on new and renewable sources of energy executed by the United Nations system. The main entities in the system active in large-scale hydropower development are the World Bank, IDA and UNDP. (Large-scale hydropower construction will not be described in this report.)

52. UNIDO has been and is still involved in projects and programmes aimed at supplying hydropower for industrial activities. In a regional African project executed between 1980 and 1987, UNIDO provided assistance to the Niger/Nigerian Joint Economic Co-operation Commission in the preparation, evaluation and execution of industrial projects and in a techno-economic analysis of providing energy to them, including hydro-electricity. UNIDO also executed, with UNDP funding, a project with the aim of establishing energy-intensive industry in connection with the Inga hydro-electric project in Zaire and a project establishing a hydro-electricity based aluminium industry in Mozambique. UNIDO has also been active in Asia, using hydro-electricity as a replacement for fuelwood in the development of the salt industry in Laos.

2. Biomass

53. The use of urban waste is treated in detail in document A/AC.218/1990/7.

54. ECE has two ongoing programmes involving biomass for industrial use. One is in the promotion of economy and efficiency in transport, which involves reporting to the Inland Transport Committee and studying the implications of using alternative transport fuels. The other programme is on low-waste and non-waste technology and the reutilization and recycling of wastes for conversion into industrial energy. ESCWA has a programme in its region on the utilization of urban and rural waste for industrial energy. One result was a technical publication published in 1987.

55. The FAO programme on fuelwood involves to some extent the promotion of technologies that would make tree-planting, charcoal-making and direct combustion for electricity or power generation more efficient. The FAO forest industries programme has promoted the use of wood waste for cogeneration or the conversion of wood to other fuels for industrial use.

56. The World Bank has an ongoing project in Mauritius involving the use of bagasse for cogeneration of energy for the sugar industry, and IDA has an ongoing biomass-to-alcohol project in Mali.

57. UNIDO is executing a project on enzymatic hydrolysis of cellulosic biomass in Brazil and a pilot project for industrial expansion, involving the production of alcohol from cassava, in north-east Thailand. In China, UNIDO has been involved in a project on an industrial biogas technology demonstration plant and experimental station in Beijing since 1981. The project covers rural industrialization and urban waste management, among other activities. It will involve anaerobic digestion of organic wastes, mainly from the distillery industry. Paraguay and Uruguay are the sites for UNIDO-executed projects on charcoal production for industrial use. In Paraguay the project involves training in charcoal production for use in the iron and steel industry. In Uruguay, it involves a study on the potential of those resources in industry. New UNIDO projects involve wood-waste utilization for charcoal production in Bhutan and Liberia.

3. Energy requirements, efficiency and management

58. Many projects involving energy efficiency and conservation, especially in relation to industrial activities, have been initiated since 1986. The regional commissions have several regular programmes involving energy conservation and efficiency.

59. ECE has had four programmes in relation to this issue during the period in question. One is on energy conservation and cogeneration potentials in the wood-processing industry; a more general energy conservation programme reports to regional senior advisors on energy-efficient technologies available in the region. ESCAP has had two programmes involving the promotion of energy efficiency in industry - one more general, and the other focusing on sail, solar and wind

applications to the services of the merchant marine and shipping. ESCWA has had a programme on energy conservation in the regional cement industry; experts have been fielded to several countries to suggest improvements in the use of energy-efficient technologies.

60. DTCD is executing two projects involving energy conservation and efficiency in industry, one in Peru and the other in India, both funded by UNDP. The World Bank has two projects in Asia that involve, in part, energy efficiency and conservation in relation to the transport sector. It supported an energy conservation project in the Republic of Korea in the highway sector and another in India in the ongoing modernization and electrification of the Indian railway system. It also supported a project in China on the modernization of a fertilizer factory which has emphasized energy savings.

61. The ILO has been involved in some training activities on improved energy conservation practices and energy management for some 30 enterprises in Bangladesh. UNIDO has, since the beginning of the 1980s, emphasized energy conservation in industry in its programmes and projects. In Brazil UNIDO executed a project funded by UNDP involving both energy conservation and substitution of imported fuels, particularly in the industrial sector. Methodologies and technical support with proposals were provided for the ceramic, cement, lime, glass, paper, food and textile industries and later for the iron, steel and chemical industries. During 1987 UNIDO organized high-level advisory services on energy conservation and substitution for the industrial sector in Haiti. Advice was given on specific measures for energy conservation covering kilns and furnaces and on the use of new and renewable sources of energy.

62. In the Asian region UNIDO has an ongoing project on the assessment of energy conservation, energy management, new and renewable sources of energy, especially hydropower, and the transfer of Japanese experience to selected industrial sectors in regional countries. Surveys have been undertaken both on plant and sectoral levels. Between 1983 and 1987 UNIDO was involved in a project in Pakistan on energy savings in industry; it related to conservation through the use of energy-efficient industrial technologies and fuel substitution. Energy conservation has been promoted from the plant level all the way to the national policy level. At the programme level, UNIDO activities include the identification and promotion of industrial investment in new and renewable sources of energy.

63. UNIDO also supported programmes supporting research and methodological activities with published reports on energy use and conservation in selected industries and, with consultations on energy-related technology and equipment, focusing on local manufacturing. UNIDO has also organized in-plant group training programmes in the field of energy savings in the cement industry. The training programmes include a component on the use of new and renewable sources of energy.

4. Other projects

64. A number of projects and programmes have involved energy sources and aspects of energy and industrialization other than those mentioned above.

65. DTCD is developing geothermal resources in the Philippines for industrial use. Both electricity generation and non-electrical applications are envisaged. ESCAP is executing a project that deals with the promotion of hydrogen as a transportation fuel, while UNIDO executed a project on industrial production of salt in Kiribati using solar ponds. UNIDO also has an ongoing project at Dehra Dun in India where alternative fuels are tested for internal combustion engines. In Monserrat UNIDO has recently completed a project on solar timber drying kilns, which includes domestic production of the equipment and a prototype.

66. During 1987 UNIDO undertook a fact-finding mission to Somalia to investigate the potential of sea-salt production using solar energy evaporation and assessing earlier attempts in that direction. A similar investigation was conducted for Trinidad and Tobago. In Jamaica a solar pilot plant was tested for use in the industrial cultivation of shellfish. In Sierra Leone low-temperature industrial water heating has been installed, and manufacturing of the equipment is also envisaged.

E. Human resources

67. The approximately 200 programmes and projects relating to new and renewable sources of energy which were executed by the United Nations system during the period 1986-1989 included some training or educational components. If success is to be achieved in transferring or introducing technology or new methodologies, training and education are essential. In many cases training involves fellowship programmes enabling experts in relevant fields from developing countries to study abroad for a limited time. Described below are projects and programmes with an emphasis on training and education, plus other programmes in the human resource category.

1. Manpower and training assessment

68. DTCD had a project in Bangladesh on the strengthening of manpower development and training in the Bangladesh Power Development Board, aimed at assessing and planning for training needs. The ILO has had three programmes on training development and manpower assessment. One programme involved co-operation with the World Bank in pre-investment energy activities, where emphasis was given to manpower assessment and training. Energy-related training was also initiated at the ILO Turin Centre. Assistance was given to member States in relation to setting up guidelines for the assessment of vocational energy-training needs. Meanwhile, UNESCO prepared a guide for teaching technologies necessary for rural development - among them, technologies using new and renewable sources of energy.

2. Priority education and training activities

69. DTCD completed a training programme for middle-level professional staff at the Ministry of Energy Resources in the Republic of Korea in energy planning and policy analysis. DTCD is also involved in the training of manpower in the geothermal sector in the Philippines.

70. ECA has a programme on training which awards three scholarships annually to African engineers, researchers and technicians in the energy field. ECE has for 10 years arranged seminars and study tours on new developments in geothermal energy. ESCAP had a meeting on techniques in energy planning in the least developed countries. ESCAP also has had about six training programmes and projects in selected technologies using new and renewable sources of energy including research and development.

71. FAO had a programme on training which aimed at strengthening training and research capabilities in relation to wood energy. It also established a forestry training institute in Viet Nam involving fuelwood. It has an ongoing project in Brazil on the training of agricultural extension workers and personnel from rural development agencies on energy issues and technologies.

72. The ILO is executing a project in Bangladesh on the development of training programmes on energy conservation, while UNDP has a project in China involving support to a biogas training centre. UNESCO has had four programmes since 1986 involving support of energy training activities: courses in solar energy conversion; post-graduate courses on current research in new and renewable sources of energy; and post-graduate courses in geothermal energy.

73. UNIDO has established a regional research, development and training centre in Asia involving mini-hydro power technology and another in Paraguay involving charcoal production. It held a training course cum workshop on minihydro in 1987 and also held a group training session on energy savings in the cement industry in Turkey in 1988.

3. Popular participation in rural energy development

74. ESCAP has established two training centres - one in Indonesia and another in Pakistan - on the use of photovoltaic power in rural areas. The centres will provide tailor-made and packaged training materials to be used for popularizing the concept of introducing the technology to rural populations.

75. The ILO had a programme on rural women and development which provided advisory services on the impact of energy policies on rural women and promoted popular participation in the planning and development of rural energy programmes. UNU has a programme on the dissemination of biogas technology in rural areas in which the rural inhabitants are encouraged to construct and execute the systems with minimal outside technical support.

4. Social, economic, cultural, labour and environmental factors

76. In recent years there has been more emphasis on the environmental aspects of development. United Nations executing agencies have increasingly adopted policies involving environmental impact statements in energy development and utilization projects. Economic aspects also receive automatic attention in the planning and implementation of projects on new and renewable sources of energy. Experience has

shown that socio-cultural aspects of energy technology need further attention. Programmes and projects dealing with such issues are described below.

77. ECE has for nine years had a programme on environmental impact assessments for sectoral activities, including energy. ESCWA prepared a comprehensive assessment in 1988 of the technical, economic and social impact of introducing biogas technology to rural areas in Syria. FAO has a programme that acts as focal point for co-ordinating environment and energy activities with other United Nations entities. Its fuelwood programme also includes environmental aspects of fuelwood use and planting.

78. The ILO has had four projects related to socio-cultural issues since 1986. A research project on the impact of energy on women's work, nutrition and health in rural areas was completed in 1987. The project was designed to convince governmental planners to take into account the enormous impact that supplying energy to poor women could have on development. Household surveys and workshops were held to discuss findings and propose further action.

79. The ILO also had a programme on technology, employment and the social implications of alternative energy policies in developing countries. The programme was aimed at strengthening the social dimension of energy policy planning in order to alleviate poverty, create employment, generate income and improve the conditions of work and life.

80. The ILO also has an energy focal point which is responsible for the co-ordination of all office work on the social and labour aspects of energy. The focal point also ensures a co-ordinated approach to technical co-operation projects in the energy sector. In Ethiopia the ILO is studying women's work-load in fuelwood transportation in Addis Ababa.

81. UNEP had two programmes involving new and renewable sources of energy and the environment. One involves the environmental impact of the production and use of biomass fuel, and the other is the development of a computerized energy/environment planning system. The World Health Organization (WHO) has an ongoing programme on the assessment of health hazards associated with energy development.

F. Information flows

82. Approximately 70 projects and programmes executed by the United Nations system during 1986-1989 mentioned information-gathering as part of the activity. Most of the information-gathering and data-base creation was geared towards the specific activity at hand, such as collecting data on reservoir property for a geothermal project. Some programmes and projects were, however, aimed at information-gathering for wider distribution, as can be noted below.

83. At the fourth session of the Committee, the Secretary-General reported on the activities in the United Nations system in information systems (A/AC.218/13) up to 1988. The paragraphs below will therefore concentrate on the programmes and projects initiated since that time or still active.

1. Regional pilot projects

84. ECA has two ongoing programmes involving information-gathering and dissemination on new and renewable sources of energy: one on research, training and information; the other, on energy conservation in mechanical wood processing industries. ECE has activities involving gathering data and disseminating information through its energy balances and energy data-bank programme. ECLAC has an ongoing programme on computer systemization of energy information, dealing mainly with energy production, pricing, consumption and trade. ESCWA also has an ongoing programme which collects and disseminates time-series energy related data from the region.

85. FAO has an ongoing programme on wood energy conversion systems in which an emphasis has been given to information. FAO also has a regional network on biogas systems in Asia which involves, to a large extent, information activities.

2. Associated priority projects based on the regional pilot projects programme

86. The Centre for Science and Technology for Development is continuing with its programme in the advance technology alert system, ATAS. During the past two years it has concentrated on new and renewable sources of energy. An ATAS Bulletin on the subject will be published shortly. UNDP is executing, with funding from the United Nations Fund for Science and Technology for Development, a technological information pilot system (TIPS), which involves, to some extent, technologies using new and renewable sources of energy.

87. UNEP is continuing its activities with the International Referral System for Sources of Environmental Information, INFOTERRA, a system which covers new and renewable sources of energy. UNEP has also, as noted, initiated a computerized energy/environment planning system which entails the creation of a data base on the subject. Meanwhile, UNESCO is expanding its activities in a network for the exchange of information on new and renewable sources of energy. Besides continuing its support of information systems around the world, it has added data bases and made them more accessible.

88. UNIDO has, as part of its energy programme, emphasized work related to information systems, particularly those on energy conservation. It is continuing its work on the Investment Promotion System, INPRIS, which contains, in addition to information, investor, bank, institution and sponsor files, country investment profiles. UNIDO has an Industrial and Technology Information Bank which publishes directories of manufacturers of energy-related equipment.

89. The United Nations Institute for Training and Research (UNITAR) and UNDP continue to co-manage the Information Centre on Heavy Crude and Tar Sands and the Centre on Small Energy Resources, both of which have a strong information-system component.

90. UNU continues to support activities by TATA Energy Research Institute in India on the Abstracts of Selected Solar Energy Technology (ASSET), which emphasizes work published in developing countries. The World Intellectual Property Organization (WIPO) offers patent information services on technical problems.

II. PROGRESS ACHIEVED

91. It is impossible to give an accurate assessment of progress achieved in the implementation of projects and programmes in the field of new and renewable sources of energy by entities within the United Nations system, because when reporting the activities, the entities did not specifically and clearly indicate the extent of implementation. None the less, the projects and programmes outlined above do cover the substantive categories listed in the report of ACC (A/AC.215/5). Not all individual projects listed in the previous report on this subject (A/AC.218/11) had actually been realized. That was to be expected. Over the years, it became necesary to update or modify some projects, even if the overall categories and programmes were still considered priority or of importance.

92. While, as noted, the substantive areas have been covered, there is no indication as to which areas received more attention than others. In a separate document on resource mobilization (A/AC.218/1990/8), an attempt has been made to indicate the value of projects executed by entities within the United Nations system according to the energy sources, as well as planning and conservation, as defined by the Nairobi Programme of Action for the Development and Utilization of New and Renewable Sources of Energy. 2/

93. In that report, the activities undertaken by the system for the periods 1982-1985 and 1986-1989 are briefly analysed. The energy sources considered include alcohol, animal power, biogas, biomass, charcoal, large-scale hydropower (greater than 10 MW), fuelwood (including plantations), new and renewable sources of energy in general, geothermal, small-scale hydropower (less than 10 MW), oilshale, ocean thermal, peat, solar, tar sands, tidal, voltaic, wave and wind.

94. In the period 1982-1985, the total value of projects executed by the system in new and renewable sources of energy was approximately $US 5.5 billion; excluding the World Bank, the value was approximately $1.3 billion. The other entities executing large projects or those with high funding level in the period 1982-1985 were the International Development Association, FAO, DTCD and UNIDO.

95. In the period 1986-1989, the value of projects was $6.4 billion, a $0.9 billion increase over the 1982-1985 period (see the table below). Most of the increase was due to an increase in the number and value of projects executed by the World Bank.

96. In 1986-1989, the World Bank, IDA, DTCD, FAO and UNIDO had the largest share. It should be noted that those entities may not necessarily have funded the projects they executed.

97. As can be seen from table 1, DIESA, ECE, ESCWA, the World Bank, UNIDO and UNITAR increased the value of executed projects and programmes from 1982-1985 to 1986-1989. The other entities registered a decrease. Overall, the energy sources involved in the projects and programmes that increased in value were biomass, charcoal, large-scale hydropower and voltaic energy. Conservation and planning also increased. All the others experienced a decrease or stayed the same. The largest increase was in large-scale hydropower ($789 million), followed by conservation ($340 million) and charcoal ($26 million). The largest decrease was for activities involving geothermal energy ($90 million), followed by biogas ($33 million) and alcohol ($28 million).

98. The World Bank increased the value of its projects and programmes by $1.1 billion; the next largest increase was by UNIDO with $18.2 million. For the other entities, increases were of the order of a few hundred thousand dollars. The World Bank's increases were represented by: large-scale hydropower projects of $870 million, $324 million in conservation, $38 million in general new and renewable sources of energy, $20 million in fuelwood, $15 million in planning and $2.5 million in biomass. The other energy sources projects executed by the World Bank experienced a decrease in value.

99. Large-scale hydropower represented approximately 64 per cent of the value of all projects executed in 1982-1985; fuelwood, 11 per cent; new and renewable sources of energy in general, 10 per cent; conservation, 5 per cent; planning, 4 per cent; and geothermal, 3 per cent. All others represented less than 1 per cent each. For the period 1986-1989, large-scale hydropower represented 67 per cent; conservation, 9 per cent; fuelwood, 9 per cent; new and renewable sources of energy in general, 8 per cent; planning, 3.5 per cent; and the rest, less than 1 per cent. It is encouraging to see that activities related to fuelwood, including efficiency of use and supply, represent a relatively large proportion of the projects since this is the major source of energy for a large part of the population in the developing world. Still, values decreased over the two periods.

Table. Value of projects executed by United Nations entities, by energy source, 1982-1985 and 1986-1989

(Thousands of United States dollars)

	1982-1985	Percentage	1986-1989	Percentage	Increase
Alcohol	31 420.4	0.57	3 285.4	0.05	(28 135.0)
Animal power	3 213.1	0.06	2 772.3	0.04	(440.8)
Biogas	45 097.3	0.82	11 455.5	0.18	(33 641.8)
Biomass	22 631.8	0.41	37 170.4	0.58	14 538.6
Charcoal	26 056.5	0.48	52 315.2	0.81	26 258.7
Conservation	267 653.3	4.89	608 409.8	9.44	340 756.5
Fuelwood	593 657.8	10.84	579 730.5	9.00	(13 927.3)
General	529 896.5	9.67	512 880.7	7.96	(17 015.8)
Geothermal	151 958.2	2.77	61 679.6	0.96	(90 278.6)
Hydro, large	3 511 732.4	64.09	4 300 845.4	66.74	789 113.0
Hydro, small	42 823.7	0.78	18 713.9	0.29	(24 109.8)
Oilshale	16 504.0	0.30	4 149.3	0.06	(12 354.7)
Ocean thermal	0.0	0.00	0.0	0.00	0.0
Peat	1 667.0	0.03	1 057.7	0.02	(609.3)
Planning	209 868.7	3.83	223 012.8	3.46	13 144.1
Solar	11 846.9	0.22	9 712.0	0.15	(2 134.9)
Tar sands	356.0	0.01	304.7	0.00	(51.3)
Tidal	216.3	0.00	0.0	0.00	(216.3)
Voltaic	2 460.5	0.04	7 766.4	0.12	5 305.9
Wave	18.6	0.00	18.6	0.00	0.0
Wind	9 900.2	0.18	8 590.0	0.13	(1 310.2)
Total	5 478 979.2	100.00	6 443 870.2	100.00	964 891.0

III. NEW PROJECT PROPOSALS ON NEW AND RENEWABLE SOURCES OF ENERGY

100. The new project proposals contained in document A/AC.218/11 were based largely on discussions held at consultative meetings up until 1986. The outline of new project proposals contained in the present report is based on information supplied by entities individually and not based on discussions of priorities.

101. ESCAP provided the Secretariat with its programme for the biennium 1990-1991. Many of the projects are a continuation of ongoing ones; for example, regional energy situations and economies, the strengthening of national capabilities in

integrated planning and the management of energy demand. It has also a programme on accelerated use of new and renewable sources of energy and another on energy conservation policies.

102. ECA intends to inititate new projects during the biennium 1990-1991 subject to approval of the programme budget. No specific indication has been given for individual projects.

103. The World Meteorological Organization (WMO) intends to initiate a meteorological information project for central and southern Europe, funded in part by UNDP. The immediate objective is the development of the capacity of national meteorological services to provide information needed in energy decision-making, particularly regarding solar and wind potentials, strengthening the links between meteorologists and energy technologists, and preparation of a specialized data base oriented towards energy studies. While the project is designed for Europe, it could serve as an example for work in other regions. The WMO/UNEP Intergovernmental Panel on Climate Change intends to conduct detailed discussions involving energy use, including new and renewable sources of energy.

104. The ILO intends to initiate a project in Zimbabwe in 1990, entitled Rural Energy and Rural Development in Communal Areas, intended to support activities to generate employment and income opportunities through improved availability of rural energy as a critical component of rural development activities.

IV. GENERAL CONCLUSIONS

105. There is continuing need for the development of new and renewable sources of energy. Entities within the United Nations system should increase their overall efforts and resources aimed at promoting the development and use of new and renewable sources of energy, energy conservation and planning.

106. Significant effort has gone into the development of large-scale hydropower, largely by the World Bank, and into such areas as conservation and planning. Efforts should be increased in the other areas.

107. Over the years, the development and the application of photovoltaic systems have increased greatly. That is to be expected, since there has been a steady decrease in the cost of photovoltaic panels as a result of advances in technology. Increased activities by the United Nations system in the form of technical and financial assistance for photovoltaic systems are called for.

108. Emphasis should be on increased and widespread utilization of mature and proven technologies. Their full dissemination should be encouraged and promoted.

Notes

1/ Official Records of the General Assembly, Forty-third Session, Supplement No. 36 (A/43/36).

2/ See Report of the United Nations Conference on New and Renewable Sources of Energy, Nairobi, 10-21 August 1981 (United Nations publication, Sales No. E.81.I.24), chap. I, sect. A.